SOIL SURVEY OF

Islands of Kauai, Oahu, Maui, Molokai, and Lanai, State of Hawaii

United States Department of Agriculture
Soil Conservation Service
in cooperation with
The University of Hawaii
Agricultural Experiment Station

Issued August 1972

Major fieldwork for this soil survey was completed in 1965. Soil names and descriptions were approved in 1967. Unless otherwise indicated, statements in the publication refer to conditions on the islands in 1965. This survey was made cooperatively by the Soil Conservation Service and The University of Hawaii Agricultural Experiment Station. It was part of the technical assistance furnished to the nine Soil and Water Conservation Districts on the islands.

Either enlarged or reduced copies of the soil map in this publication can be made by commercial photographers, or they can be purchased, on individual order, from the Cartographic Division, Soil Conservation Service, United States Department of Agriculture, Washington, D.C. 20250.

HOW TO USE THIS SOIL SURVEY

THIS SURVEY contains information that can be applied in managing farms, ranches, and woodlands; in selecting sites for roads, ponds, buildings, or other structures; and in appraising the suitability of tracts of land for farming, ranching, industry, or community development.

Locating Soils

All the soils on the islands of Kauai, Oahu, Maui, Molokai, and Lanai are shown on the detailed map at the back of this survey. This map consists of many sheets that are made from aerial photographs. Each sheet is numbered to correspond with numbers shown on the Index to Map Sheets.

On each sheet of the detailed map, soil areas are outlined and are identified by symbol. All areas marked with the same symbol are the same kind of soil. The soil symbol is inside the area if there is enough room; otherwise, it is outside and a pointer shows where the symbol belongs.

Finding and Using Information

The "Guide to Mapping Units" can be used to find information in this publication. This guide lists all of the soils on the islands in alphabetic order by map symbol. It shows the page where each kind of soil is described, the classification of the soil by capability class and subclass, and also the page for the sugarcane group, the pineapple group, the pasture group, and the woodland group in which the soil has been placed.

Interpretations not included in the text can be developed by grouping the soils according to their suitability or limitations for a particular use. Translucent material can be used as an overlay over the soil map and colored to show soils that have the same limitation or suitability. For example, soils that have a slight limitation for a given use can be colored green, those with a moderate limitation can be colored yellow, and those with a severe limitation can be colored red.

Farmers and those who work with them can learn about use and management of the soils from the soil descriptions and from the discussions of the sugarcane groups, the pineapple groups, the pasture groups, and the woodland groups.

Ranchers and others interested in pasture can find under "Pasture Management," information about the suitability of the soils for pasture and the kind of plants that grow on the islands.

Foresters and others can refer to "Woodland Management" to learn about the suitability of the soils for trees.

Engineers and builders will find under "Engineering Uses of the Soils," tables that describe soil properties that affect engineering and show the relative stability of the soil for specific engineering purposes.

Scientists and others can read about how the soils are classified and how they formed in the section "Classification, Genesis, and Morphology of the Soils."

Newcomers on the islands may be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the section "General Nature of the Islands" where history, geography, climate, and other general information are given.

Cover picture: **Mt. Kahili forms backdrop for part of fertile, green grazing paddocks on island of Kauai. Steep mountain slopes are maintained in tree and shrub cover for soil protection. Grazing paddocks are Puhi silty clay loams. Steep slopes are Rough broken land.**

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SOIL SURVEY OF THE ISLANDS OF KAUAI, OAHU, MAUI, MOLOKAI, AND LANAI, STATE OF HAWAII

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UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, IN COOPERATION WITH THE UNIVERSITY OF HAWAII AGRICULTURAL EXPERIMENT STATION

KAUAI, OAHU, MAUI, MOLOKAI, and LANAI—five of the eight major islands in the State of Hawaii—make up the survey area (fig. 1). The Hawaiian Islands, the 50th State of the United States, lie in the Pacific Ocean about 2,100 miles west southwest of San Francisco, California. Honolulu, on the island of Oahu is the principal city and the State capital. It is on the crossroads of the Pacific and serves as a gateway to Asia and the South Pacific.

The area surveyed covers 1,463,820 acres, or 2,287 square miles. The total land area of Kauai is 355,000 acres, or 555 square miles; Oahu 386,500 acres, or 604 square miles;

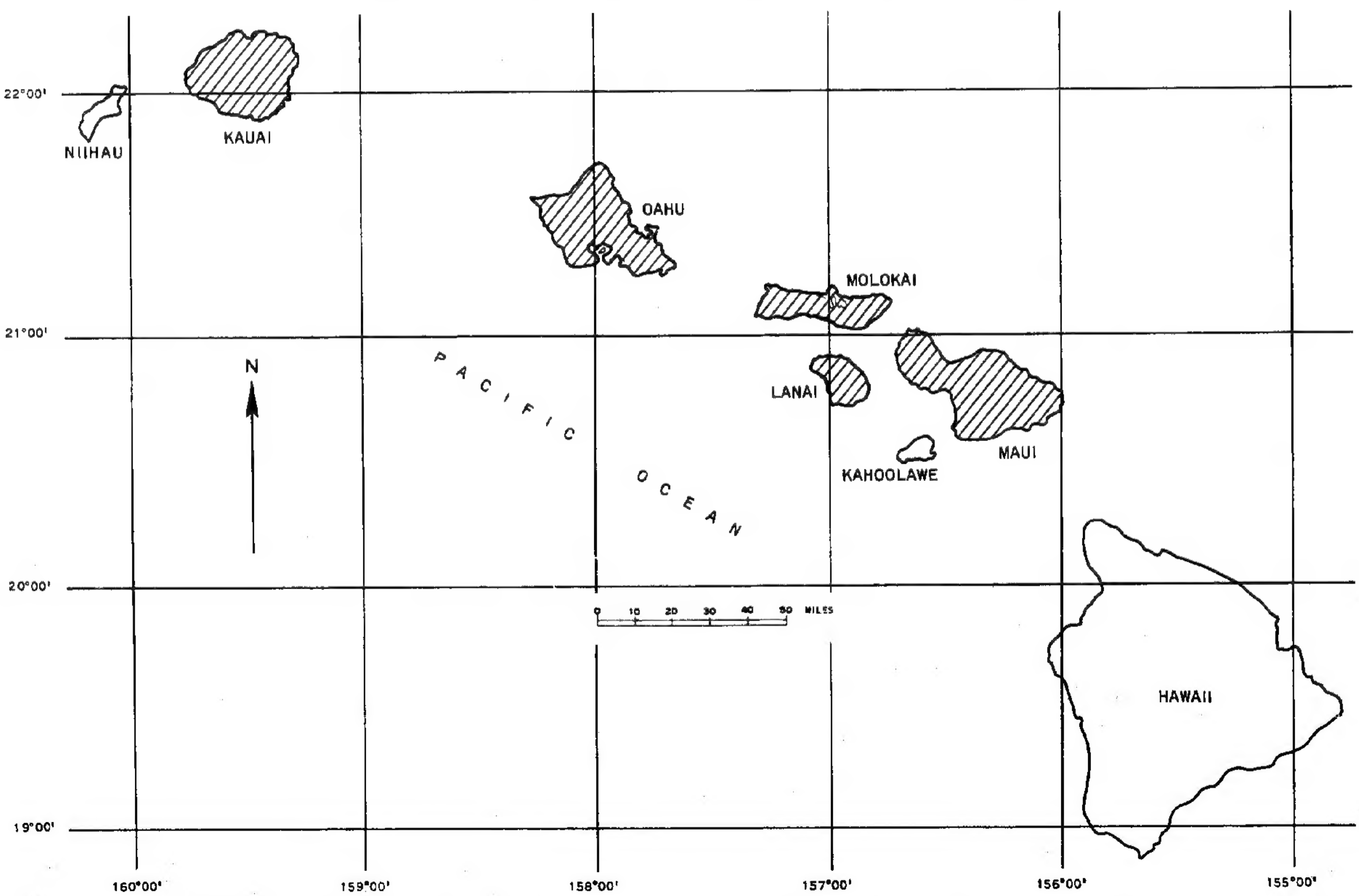

Figure 1.—**Location of the islands of Kauai, Oahu, Maui, Molokai, and Lanai, State of Hawaii.**

Maui 465,920 acres, or 728 square miles; Molokai 166,400 acres, or 260 square miles; and Lanai 90,000 acres, or 140 square miles.

Most of the soils on the islands formed in volcanic material. A few formed in organic material and coral sand. The climate is characterized by mild temperatures. Annual rainfall, most of which occurs during the period October to April, ranges from 10 inches to more than 400 inches.

The economy of the islands depends mainly on farming and ranching and on tourism. Sugarcane and pineapple are the principal crops. Cattle ranching is the principal livestock industry.

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soil are on the islands, where they are located, and how they can be used. They observed the steepness, length, and shape of slopes, the size and speed of streams, the kinds of native plants or crops, the kinds of rock, and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material that has not been changed much by leaching or by the action of plant roots.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those on other islands of the United States and in places more distant. They classified and named the soils according to nationwide, uniform procedures. The *soil series* and the *soil phase* are the categories of soil classification most used in a local survey (*16*).[1]

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Molokai and Lahaina, for example, are the names of two soil series. All the soils of the United States having the same series name are essentially alike in those characteristics that affect their behavior in the undisturbed landscape.

Soils of one series can differ in texture of the surface soil and in slope, stoniness, or some other characteristic that affects use of the soils by man. On the basis of such differences, a soil series is divided into phases. The name of a soil phase indicates a feature that affects management. For example, Molokai silty clay loam, 7 to 15 percent slopes, severely eroded, is one of several phases within the Molokai series.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show woodlands, buildings, field borders, trees, and other details that help in drawing boundaries accurately. The soil map in the back of this publication was prepared from the aerial photographs.

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in planning the management of fields, a mapping unit is nearly equivalent to a soil phase. It is not exactly equivalent, because it is not practical to show on such a map all the small, scattered bits of soil of some other kind that have been seen within an area that is dominantly of a recognized soil phase.

Some mapping units are made up of soils of different series, or of different phases within one series. Two such kinds of mapping units are shown on the soil map of the islands: soil complexes and soil associations.

A soil complex consists of areas of two or more soils, so intermingled or so small in size that they cannot be shown separately on the soil map. Each area of a complex contains some of each of the two or more dominant soils, and the pattern and relative proportions are about the same in all areas. The name of a soil complex consists of the names of the dominant soils, joined by a hyphen. Kemoo-Badland complex is an example.

A soil association is made up of adjacent soils that occur as areas large enough to be shown individually on the soil map but are shown as one unit because the time and effort of delineating them separately cannot be justified. There is a considerable degree of uniformity in pattern and relative extent of the dominant soils, but the soils may differ greatly one from another. The name of an association consists of the names of the dominant soils, joined by a hyphen. Amalu-Olokui association is an example.

In most areas surveyed there are places where the soil material is so rocky, so shallow, or so severely eroded that it cannot be classified by soil series. These places are shown on the soil map and are described in the survey, but they are called land types and are given descriptive names. Gullied land is a land type on the islands.

While a soil survey is in progress, samples of soils are taken, as needed, for laboratory measurements and for engineering tests. Laboratory data from the same kinds of soil in other places are assembled. Data on yields of crops under defined practices are assembled from farm or plantation records and from field or plot experiments on the same kinds of soil. Yields under defined management are estimated for all the soils.

But only part of a soil survey is done when the soils have been named, described, and delineated on the map, and the laboratory data and yield data have been assembled. The mass of detailed information then needs to be organized in such a way as to be readily useful to different groups of users, among them farmers, managers of woodland and rangeland, and engineers.

On the basis of yield and practice tables and other data, the soil scientists set up trial groups. They test these groups by further study and by consultation with farmers, agronomists, engineers, and others, then adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under present methods of use and management.

General Soil Map

The general soil maps at the back of this survey show, in color, the soil associations on the islands of Kauai, Oahu, Maui, Molokai, and Lanai, State of Hawaii. A

[1] Italic numbers in parentheses refer to Literature Cited, page 230.

soil association is a landscape that has a distinctive proportional pattern of soils. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association may occur in another, but in a different pattern.

A map showing soil associations is useful to people who want a general idea of the soils on the Hawaiian Islands, who want to compare different parts of the islands, or who want to know the location of large tracts that are suitable for a certain kind of land use. Such a map is a useful general guide in managing a watershed, a wooded tract, or a wildlife area, or in planning engineering works, recreational facilities, and community developments. It is not a suitable map for planning the management of a farm or field, or for selecting the exact location of a road, building, or similar structure, because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage, and other characteristics that affect their management.

The islands of Kauai, Oahu, Maui, Molokai, and Lanai, and the soil associations on each are described in the following pages.

Island of Kauai

Kauai is the northernmost and the fourth largest island in the State. It is 33 miles long and 25 miles wide. The land area is 355,000 acres, or 555 square miles. The island rises to its highest point, 5,170 feet, at Kawaikini Peak, which is near the center of the island. The Kauai volcano is believed to have formed late in the Tertiary period (*7*). After the completion of the Kauai shield cone, there was a long period of erosion during which no volcanic activity occurred. The Koloa volcanics occurred later and covered many of the eroded areas. Waves cut high cliffs around the island and streams cut deep canyons. The north and central parts of the islands are not easily accessible. They consist chiefly of canyons and steep mountain slopes and the Alakai swamp.

Nearly all the farm and ranch land and the populated areas on the island are on the low uplands along the coast. These low coastal uplands circle the island except for part of the northwest coast.

Because of its lush vegetation and beautiful mountains, Kauai is commonly referred to as the Garden Island. Lihue is the population, business, and cultural center. It has an airport. Nawiliwili and Hanapepe have deepwater harbors.

Two of the island's three pineapple canneries were closed in recent years. Some of the abandoned pineapple land is used for sugarcane, some for pasture, and some for papayas.

During the last few years, hotels have been built in the Wailua, Nawiliwili, and Poipu areas to accommodate the increasing number of tourists.

1. Jaucas-Mokuleia association

Deep, nearly level to moderately sloping, excessively drained and well-drained soils that have coarse-textured underlying material; on coastal plains

This association consists of excessively drained and well-drained soils in dunes and on former beach areas on the island of Kauai. These soils are nearly level to moderately sloping. They developed in coral or basaltic sand. The association makes up about 1 percent of the island.

The elevation ranges from near sea level to 150 feet. The annual rainfall is 20 to 100 inches. The mean annual soil temperature is 74° or 75° F. The natural vegetation is kiawe, klu, feather fingergrass, sandbur, koa haole, and bermudagrass.

Jaucas soils make up about 60 percent of the association and Mokuleia soils 25 percent. Dune land and Jaucas soils, dark variant, make up the rest.

Jaucas soils have a surface layer of pale-brown to grayish-brown, very friable loamy fine sand to sand. The substratum is light-colored loose sand. Mokuleia soils have a surface layer of very dark-brown, friable fine sandy loam. The substratum is dark-brown to dark grayish-brown, loose fine sand to sand.

This association is used for irrigated sugarcane, irrigated alfalfa, pasture, and wildlife habitat. Mokuleia and Jaucas soils are used mainly for pasture. Irrigated areas of Jaucas soils are used for sugarcane and alfalfa. Jaucas soils are also used as a source of sand. Upland game birds are the principal kinds of wildlife.

2. Hanalei-Kolokolo-Pakala association

Deep, nearly level, poorly drained to well-drained soils that have dominantly moderately fine textured or medium-textured subsoil or underlying material; on bottom land

This association consists of poorly drained to well-drained soils on bottom land on the island of Kauai. These soils are nearly level. They developed in alluvium. The association makes up about 2 percent of the island.

The elevation ranges from near sea level to 500 feet. The annual rainfall is 25 to 150 inches. The mean annual soil temperature is about 74° F. The natural vegetation is koa haole, kiawe, bermudagrass, mango, californiagrass, sensitiveplant, honohono, java plum, pangolagrass, kikuyugrass, guava, pandanus, glenwoodgrass, ricegrass, and hau.

Hanalei soils make up about 45 percent of the association, Kolokolo soils 25 percent, and Pakala soils 20 percent. Mokuleia soils, poorly drained variant, make up the rest.

Hanalei soils have a surface layer of mottled dark grayish-brown to mottled very dark gray, firm silty clay, silty clay loam, or peaty silty clay loam. Their subsoil is mottled, dark-gray to dark grayish-brown, firm silty clay or silty clay loam. The substratum is stratified alluvium. Kolokolo soils have a surface layer of very dark brown, friable silty clay loam, loam, or extremely stony clay loam. This layer is underlain by brown to very dark-brown, friable loam to silty clay loam. The substratum is stratified alluvium. Pakala soils have a surface layer of dark reddish-brown, firm clay loam or extremely stony clay loam. Below this is very dusky red to dark reddish-brown, very friable very fine sandy loam to silt loam. The substratum is stratified alluvium.

This association is used for irrigated sugarcane, irrigated taro, irrigated truck crops, pasture, and wildlife habitat. All of the soils are used for pasture. Irrigated areas of Hanalei and Pakala soils are used for sugarcane and truck crops. Hanalei soils are also used for taro.

Upland game birds make up most of the wildlife population.

3. Kekaha-Nohili association

Deep, nearly level, well-drained and poorly drained soils that have a fine-textured subsoil; on coastal plains

This association consists of well-drained and poorly drained, medium-textured to very fine textured soils on the Mana coastal plain on the island of Kauai. These soils are nearly level. They developed in alluvium. The association makes up about 2 percent of the island.

The elevation ranges from near sea level to 80 feet. The annual rainfall is 20 to 23 inches. The mean annual soil temperature is about 75° F. The natural vegetation is koa haole, kiawe, klu, and fingergrass.

Kekaha soils make up about 45 percent of the association and Nohili soils 15 percent. Fill land and Kaloko, Lualualei, and Mamala soils make up the rest.

Kekaha soils have a surface layer of dark reddish-brown, friable silty clay, clay, or extremely stony silty clay loam. The subsoil is dark reddish-brown, firm silty clay or clay. The substratum is stratified alluvium and marine clay. Nohili soils have a surface layer of dark reddish-brown, firm clay and a subsoil of dark-brown to very dark-gray, mottled, firm clay. The substratum is marly clay.

This association is used for irrigated sugarcane, irrigated truck crops, and pasture. Sugarcane is the chief crop and is grown on all of the soils. Extremely stony phases of Kekaha soils are used for pasture. Nohili soils require drainage.

4. Kapaa-Pooku-Halii-Makapili association

Deep, nearly level to steep, well drained and moderately well drained soils that have a fine textured or moderately fine textured subsoil; on uplands

This association consists of well drained and moderately well drained, fine-textured soils on the uplands of East Kauai. These soils are nearly level to steep. They developed in material weathered from basic igneous rock. The association makes up about 10 percent of the island.

The elevation ranges from 100 to 1,000 feet. The annual rainfall is 70 to 200 inches. The mean annual soil temperature is between 72° and 74° F. The natural vegetation is melastoma, rhodomyrtus, guava, ricegrass, hilograss, yellow foxtail, Christmas berry, false staghornfern, pangolagrass, kikuyugrass, kaimiclover, sensitiveplant, java plum, and joee.

Kapaa soils make up about 40 percent of the association, Pooku soils 25 percent, Halii soils 20 percent, and Makapili soils 5 percent. Rough broken land and other soils make up the rest.

Kapaa soils have a surface layer of dark-brown to dark yellowish-brown, friable silty clay. The subsoil is yellowish-red to reddish-brown, friable silty clay and clay loam. The substratum is soft, weathered basic igneous rock. Pooku soils have a surface layer of dark-brown to dark yellowish-brown, friable silty clay. The subsoil is a dark-red to dark reddish-brown, friable silty clay loam to silty clay. The substratum is soft, weathered basic igneous rock. Halii soils have a surface layer of very dark grayish-brown, friable gravelly silty clay loam to gravelly silty clay and a subsoil of dark reddish-brown to dark-brown, friable clay loam to silty clay. The substratum is soft, weathered basic igneous rock. Makapili soils have a surface layer of dark-brown to very dark grayish-brown, friable silty clay and a subsoil of dark reddish-brown, firm clay loam to silty clay. The substratum is soft, weathered basic igneous rock.

This association is used for sugarcane, pasture, pineapple, woodland, wildlife habitat, and water supply. Pooku and Makapili soils are used mainly for pasture, Kapaa soils for sugarcane, and Halii soils for water supply. Upland game birds and wild pigs are the principal kinds of wildlife.

5. Lihue-Puhi association

Deep, nearly level to steep, well-drained soils that have a fine textured or moderately fine textured subsoil; on uplands

This association consists of well-drained, medium-textured and fine-textured soils on the uplands of South and East Kauai. These soils are nearly level to steep. They developed in material weathered from basic igneous rock. The association makes up about 12 percent of the island.

The elevation ranges from near sea level to 800 feet. The annual rainfall is 40 to 80 inches. The mean annual soil temperature is about 73° F. The natural vegetation is guava, java plum, pangolagrass, kikuyugrass, elephantopus, joee, yellow foxtail, rhodomyrtus, lantana, koa haole, molassesgrass, guineagrass, and bermudagrass.

Lihue soils make up about 40 percent of the association and Puhi soils 35 percent. Ioleau, Koloa, and other soils, and areas of Rough broken land make up the rest.

Lihue soils have a surface layer of dusky-red to dark reddish-brown, firm to friable silty clay. The subsoil is dark-red to dark reddish-brown, firm silty clay. The substratum is soft, weathered basic igneous rock. Puhi soils have a surface layer of brown to very dark-brown, friable silty clay loam. The subsoil is reddish-brown to dark-brown, friable silty clay loam and silty clay. The substratum is soft, weathered basic igneous rock.

This association is used for irrigated sugarcane, pineapple, pasture, woodland, and wildlife habitat. Sugarcane is the main crop. Upland game birds make up most of the wildlife population.

6. Makaweli-Waiawa-Niu association

Deep, gently sloping to steep, well-drained soils that have a dominantly moderately fine textured or fine textured subsoil and shallow, steep and very steep, well-drained soils over basalt bedrock; on uplands

This association consists of well-drained, moderately fine textured and fine textured soils on the uplands of South and West Kauai. These soils are gently sloping to very steep. They developed in material weathered from basic igneous rock. The association makes up about 9 percent of the island.

The elevation ranges from near sea level to 2,000 feet. The annual rainfall is 20 to 40 inches. The mean annual soil temperature is between 69° and 74° F. The natural vegetation is kiawe, lantana, fingergrass, klu, koa haole, piligrass, aalii, guineagrass, indigo, and cactus.

Makaweli soils make up about 45 percent of the association, Waiawa soils 30 percent, and Niu soils 10 percent. Rough broken land and other soils make up the rest.

Makaweli soils have a surface layer of dusky-red to dark reddish-brown, friable silty clay loam or stony silty clay loam. The subsoil is dusky-red, friable silt loam and silty clay loam. The substratum is soft, weathered basic igneous rock that in places contains hard boulders. Waiawa soils have a surface layer of dark reddish-brown, very firm very rocky clay loam or very rocky clay. This layer is underlain by hard basic igneous rock. Niu soils have a surface layer of dusky-red to dark reddish-brown, friable silty clay loam to silty clay. The subsoil is dark-red, friable silty clay loam or silty clay. The substratum is soft, weathered basic igneous rock.

This association is used for irrigated sugarcane, pasture, woodland, and wildlife habitat. Makaweli and Niu soils are used mainly for sugarcane. A small acreage of Makaweli soils is used for irrigated pasture. Waiawa soils are used only for pasture. Upland game birds, wild pigs, and wild goats are the principal kinds of wildlife.

7. Waikomo-Kalihi-Koloa association

Moderately deep, gently sloping, well-drained upland soils that have a moderately fine textured or fine textured subsoil; deep, nearly level, poorly drained, bottom-land soils that have a fine-textured subsoil

This association consists of well-drained, fine-textured soils that developed in material weathered from basic igneous rock and poorly drained, very fine-textured soils that developed in alluvium. These soils are gently sloping to nearly level and are on the uplands and bottom lands of Southeast Kauai. The association makes up about 2 percent of the island.

The elevation ranges from near sea level to 360 feet. The annual rainfall is 35 to 60 inches. The mean annual soil temperature is between 72° and 74° F. The natural vegetation is lantana, koa haole, java plum, cactus, swollen fingergrass, bermudagrass, and guineagrass.

Waikomo soils make up about 70 percent of the association, Kalihi soils 20 percent, and Koloa soils 10 percent.

Waikomo soils have a surface layer of dark-brown to very dark grayish-brown, very firm stony silty clay. The subsoil is reddish-brown to dark yellowish-brown, firm heavy silty clay loam. The substratum is hard basic igneous rock. Kalihi soils have a surface layer of very dark-gray to mottled dark-brown, firm clay. The subsoil is dark-gray, mottled, firm clay. The substratum is grayish-brown and dark-gray, firm clay. Koloa soils have a surface layer of dark reddish-brown, firm stony silty clay. The subsoil is dusky-red to dark reddish-brown, firm silty clay. The substratum is hard rock.

This association is used for irrigated sugarcane, pasture, and wildlife habitat. Sugarcane is the chief crop and is grown on all the soils. Pasture is grown only on Waikomo soils. Upland game birds are the principal kinds of wildlife.

8. Rough broken land-Mahana-Kokee association

Shallow to deep, very steep, rough broken land and deep, moderately sloping to very steep, well-drained soils that have a medium-textured to fine-textured subsoil; on uplands

This association consists of well-drained, medium-textured and fine-textured soils on the uplands of South and West Kauai. These soils are moderately sloping to very steep. They developed in material weathered from volcanic ash and basic igneous rock. The association makes up about 9 percent of the island.

The elevation ranges from 1,500 to 4,200 feet. The annual rainfall is 30 to 70 inches. The mean annual soil temperature is between 58° and 66° F. The natural vegetation is ohia lehua, pukiawe, blackberry, yellow foxtail, koa, plantain, uki uki, redwood, aalii, ricegrass, molassesgrass, silver oak, lantana, joee, Japanese tea, passion flower, Boston fern, and uki.

Rough broken land makes up about 35 percent of the association, Mahana soils 20 percent, and Kokee soils 20 percent. Oli, Paaiki, and Puu Opae soils make up the remaining 25 percent.

Rough broken land is very steep. The soil material ranges from very shallow to deep over hard, weathered basic igneous rock.

Mahana soils have a surface layer of dusky-red to dark reddish-brown, friable loam to silty clay loam. The subsoil is dark-red to dusky-red, very friable very fine sandy loam to silty clay loam. The substratum is soft, weathered basic igneous rock. Kokee soils have a surface layer of dark-brown to very dark brown, friable silty clay loam. The subsoil is strong-brown to dark yellowish-brown, friable silty clay loam to silty clay. The substratum is hard and soft, weathered basic igneous rock.

This association is used for pasture, woodland, wildlife habitat, water supply, and irrigated sugarcane. Mahana soils are used chiefly for pasture. Small acreages are irrigated and are in sugarcane. Kokee soils are used chiefly for woodland. Upland game birds, wild pigs, wild goats, and deer are the principal kinds of wildlife.

9. Waialeale-Alakai association

Moderately deep, very steep, somewhat poorly drained soils that have a moderately fine textured subsoil and level to moderately steep, very poorly drained organic soils over fine-textured material; on uplands

This association consists of somewhat poorly drained to very poorly drained, organic soils on the uplands of Central Kauai. These soils are level to very steep. They developed in organic debris deposited on basic igneous rock. The association makes up about 3 percent of the island.

The elevation ranges from 3,500 to 5,000 feet. The annual rainfall is 100 to 450 inches. The mean annual soil temperature is between 56° and 59° F. The natural vegetation is ohia lehua, Hawaiian lobelia, mokihana, pukiawe, treefern, lapalapa, brackenfern, and uki uki.

Waialeale soils make up about 50 percent of the association and Alakai soils 35 percent. Rough broken land makes up the rest.

Waialeale soils have a surface layer of dark reddish-brown, friable mucky peat. The subsoil is dark-brown to strong-brown, friable gravelly silty clay loam. The substratum is hard, weathered basic igneous rock. Alakai soils have a surface layer of dark reddish-brown to very dusky-red, friable mucky peat. Below this is black,

friable muck, and below the muck, gray to greenish-gray, firm clay.

This association is used for water supply and wildlife habitat. Wild goats and wild pigs are the chief kinds of wildlife.

10. Rough mountainous land-Rough broken land-Rock outcrop association

Well-drained to excessively drained, very steep to precipitous lands of mountains and gulches

This association consists of well-drained to excessively drained land types on uplands on the island of Kauai. The areas are very steep to precipitous. The association makes up about 50 percent of the island.

The elevation ranges from near sea level to 5,170 feet. The annual rainfall amounts to as little as 22 inches in leeward lowlands and as much as 450 inches over windward slopes of Mt. Waialeale. The mean annual soil temperature is between 56° and 74° F. The natural vegetation is false staghornfern, ohia lehua, java plum, kiawe, and koa haole.

Rough mountainous land makes up about 45 percent of the association, Rough broken land 30 percent, and Rock outcrop 25 percent.

Rough mountainous land is very steep. In most places elevations exceed 500 feet. The soil material is generally shallow over hard, weathered basic igneous rock. Rough broken land is very steep. The soil material is very shallow to deep over hard, weathered basic igneous rock. Rock outcrop is more than 90 percent bedrock. It occurs on very steep slopes or on precipitous cliffs.

This association is used for water supply, pasture, woodland, and wildlife habitat. Rough mountainous land and Rock outcrop serve mainly as watershed. Upland game birds, wild goats, and wild pigs are the principal kinds of wildlife.

Island of Oahu

Oahu, the third largest island in the State, is 44 miles long and 30 miles wide. The land area is 386,560 acres, or 604 square miles. The island is divided into four main areas—the Waianae Range, the Koolau Range, the Schofield Plateau, and the coastal plains.

The Waianae Range, on the western part of the island, is about 22 miles long. It is rough and mountainous and has narrow ridges and very steep slopes. It rises to 4,025 feet, which is the highest point on the island.

The Koolau Range, on the eastern part of the island, is 37 miles long. It is deeply dissected by numerous drainageways. Along the northern side is a sheer cliff that rises from the ocean's edge to a height of as much as 2,500 feet.

The Schofield Plateau lies between the two mountain ranges. The soils on the plateau are well suited to cultivation, and a large acreage is used for sugarcane and pineapple.

The coastal plains adjacent to the ocean formed from coral reefs and alluvial sediments. They have smooth, gentle slopes. They are used mostly for farming and ranching or for urban development. There are several volcanic cones, such as Diamond Head, Salt Lake Crater, and Punchbowl, near Honolulu.

An important source of water supply is an exceptional lens of basal ground water in the Honolulu-Pearl Harbor area. Smaller accumulations of basal ground water occur in other parts of the island. Another important source of water on Oahu is the high-level ground water that is confined between lava dikes. The supply of ground water is replenished by abundant rainfall in the mountainous areas.

Honolulu, the principal city on Oahu, is the business, cultural, and political center of the State of Hawaii. More than four-fifths of the population of Hawaii lives on Oahu. This is the only island where farming and ranching are not the major economic activities. The visitor industry and federal expenditures exceed the production of pineapple and sugar as the top sources of income.

1. Lualualei-Fill land-Ewa association

Deep, nearly level to moderately sloping, well-drained soils that have a fine textured or moderately fine textured subsoil or underlying material, and areas of fill land; on coastal plains

This association consists of well-drained, fine textured and moderately fine textured soils on fans and in drainageways on the southern and western coastal plains on the island of Oahu. The soils are nearly level to moderately sloping. They formed in alluvium. The areas of Fill land consist of many kinds of material. The association makes up about 14 percent of the island.

The elevation ranges from sea level to 400 feet. The annual rainfall is 15 to 30 inches in most places but is as much as 50 inches in some of the valleys. Most of the rain falls between November and April. Summers are hot and dry. The mean annual soil temperature is between 73° and 75° F. The natural vegetation is kiawe, koa haole, and fingergrass.

Lualualei soils make up about 20 percent of the association, Fill land about 20 percent, and Ewa soils 15 percent. Honouliuli, Jaucas, Kawaihapai, Makalapa, Mamala, and Pulehu soils make up the rest.

Lualualei soils have a surface layer of very dark grayish-brown, very sticky and very plastic clay that cracks widely upon drying. They are underlain by coral, gravel, sand, or clay at a depth below 40 inches. Fill land consists of various kinds of fill material. Ewa soils have a surface layer and subsoil of dark reddish-brown, friable silty clay loam. The substratum is gravelly alluvium or coral limestone.

This association is used for sugarcane, truck crops, pasture, and urban development. Fill land is used mainly for airports and industrial and homesites. Areas that have been built up from mill wastes are used for sugarcane.

2. Helemano-Wahiawa association

Deep, nearly level to moderately sloping, well-drained soils that have a fine-textured subsoil; on uplands

This association consists of well-drained, moderately fine textured and fine textured soils on uplands on the island of Oahu. These soils are nearly level to moderately sloping and occur in broad areas dissected by very steep gulches. They formed in material weathered from basalt. The association makes up about 18 percent of the island.

The elevation ranges from 100 to 1,200 feet. The annual rainfall is 25 to 50 inches in most areas but is as much as 60 inches in some. Most of it falls in winter. The mean annual soil temperature is between 71° and 73° F. The natural vegetation is guava, koa haole, lantana, joee, and bermudagrass.

Helemano soils make up about 40 percent of the association, and Wahiawa soils 30 percent. Kunia, Lahaina, and Molokai soils make up the rest.

Helemano soils are dark reddish-brown silty clays. They occur on the sides of very steep gulches and have slopes of 30 to 90 percent. Wahiawa soils have a surface layer of very dusky red silty clay, a subsoil of dark reddish-brown silty clay, and a substratum of soft weathered rock. They are on uplands and have slopes of 0 to 25 percent.

Helemano soils are used for pasture. Large acreages of Wahiawa soils are used for sugarcane and pineapple. Sugarcane is grown under irrigation. Pineapple is irrigated only in the driest areas.

3. Tropohumults-Dystrandepts association

Gently sloping to very steep, well-drained soils that are underlain by soft weathered rock, volcanic ash, or colluvium; on narrow ridges and side slopes

This association consists of the mountainous areas and lower slopes of the Waianae Range on the island of Oahu. The soils are gently sloping to very steep, well drained, and fine textured to moderately fine textured. The association makes up about 8 percent of the island.

The elevation ranges from 600 to 4,000 feet. The annual rainfall is 30 to 75 inches. The mean annual soil temperature is between 56° and 71° F. Lantana, yellow foxtail, molassesgrass, and Japanese tea grow at the lower elevations, and ohia lehua, pukiawe, koa, aalii, and ferns at the upper elevations.

Tropohumults and Dystrandepts make up about 55 percent of the association. The rest is made up of Mahana, Kolekole, Halawa, Helemano, and Alakai soils and areas of Rock land, Rock outcrop, and Stony land.

Tropohumults occur on the narrow ridges at the upper elevations. They have a surface layer and subsoil of reddish-brown silty clay. They are underlain by soft weathered rock. Dystrandepts occur in concave positions on the steep side slopes. They were derived dominantly from volcanic ash mixed with colluvium. They are dark colored and have a surface layer of silt loam or silty clay loam. Their subsoil is massive.

Most of this association is very steep and inaccessible. It is used mainly for watershed. Some of the minor soils are used for woodland and pasture, and some for pineapple and sugarcane.

4. Rough mountainous land-Kapaa association

Very steep land broken by numerous drainageways and deep, well-drained soils that have a fine textured or moderately fine textured subsoil; in gullies and on narrow ridges

This association consists of very steep land broken by numerous drainageways. It occurs on Oahu and makes up about 20 percent of the island.

The elevation ranges from 1,000 to 3,000 feet. Rainfall is fairly well distributed throughout the year. The annual amount ranges from 70 inches at the lowest elevations to 250 inches near the mountain summit. The mean annual soil temperature is between 60° and 71° F. The natural vegetation is ohio lehua, koa, treefern, false staghorn, fern, hilograss, and sedges.

Rough mountainous land makes up about 80 percent of the association and Kapaa soils about 15 percent. Rock land and Rock outcrop make up the rest.

Rough mountainous land consists of very steep gulches and narrow ridges. The soil material is very shallow, very dark grayish-brown, smeary silty clay. Kapaa soils are in very steep gulches and on narrow ridges at the northern end of the island. They have a surface layer and subsoil of dark reddish-brown silty clay that contains gibbsite nodules.

This association is inaccessible except for a few trails used by hunters and hikers. It is used for watershed and wildlife habitat. Gently sloping areas of Kapaa soils are suited to timber. The heavy rainfall is an important factor in recharging the supply of ground water. The most important wildlife species is wild pigs.

5. Rock land-Stony steep land association

Steep to precipitous, well-drained to excessively drained, rocky and stony land

This association consists of stony and rocky, steep to precipitous slopes. It occurs on Oahu and makes up about 15 percent of the island.

The elevation ranges from sea level to 2,800 feet. The annual rainfall is 15 to 50 inches in most areas but is as much as 200 inches along the windward cliffs of the Koolau Range. The mean annual soil temperature is between 67° and 75° F. Kiawe, buffelgrass, and fingergrasses grow in the drier areas, and ohia lehua, ferns, and sedges in the wetter areas.

Rock land makes up about 60 percent of the association, and Stony steep land 15 percent. Rock outcrop, Stony land, and areas of Kawaihapai, Lualualei, and Pulehu soils make up the rest.

Rock land is 25 to 90 percent rock outcrop. It is very steep and occurs in gulches and on mountainsides. The soil material is very shallow. Stony steep land is a mass of boulders and stones deposited by water or gravity in valley bottoms or on side slopes of drainageways. Slopes are very steep.

This association is used mainly for pasture, wildlife habitat, and recreation. Some areas are used for homesites. Upland game birds and wild pigs are the principal kinds of wildlife.

6. Kaena-Waialua association

Deep, mainly nearly level and gently sloping, poorly drained to excessively drained soils that have a fine-textured to coarse-textured subsoil or underlying material; on coastal plains and talus slopes and in drainageways

This association occurs as a narrow band along the northern and eastern coastline on the island of Oahu. The soils occur in drainageways, on coastal plains, and on talus slopes. They are nearly level and gently sloping for the most part but are steeper on talus slopes. They formed in alluvium and vary widely in texture and

drainage. The association makes up about 10 percent of the island.

The elevation ranges from sea level to 200 feet. The annual rainfall is generally 30 to 45 inches but ranges from 20 to 80 inches. Most of the rain falls in winter. Summer showers are common. The mean annual soil temperature is about 74° F. Kiawe, koa haole, and fingergrasses grow in the drier areas, and guava, java plum, and californiagrass in the wetter areas.

Kaena and Waialua soils make up about 50 percent of the association. Hanalei, Kawaihapai, Jaucas, Haleiwa, Kaloko, Keaau, Mokuleia, Pearl Harbor, and Pulehu soils, and areas of Coral outcrop and Marsh make up the rest.

Kaena soils are poorly drained, dark-colored silty clays or clays underlain by alluvium. Waialua soils are moderately well drained, dark reddish-brown silty clays or clays underlain by alluvium.

This association is used for sugarcane, truck crops, pasture, orchard, recreation, and urban development. Kaena soils need to be drained before they can be cultivated.

7. Lolekaa-Waikane association

Deep, nearly level to very steep, well-drained soils that have a dominantly fine-textured subsoil; on fans, terraces, and uplands

This association consists of well-drained, fine textured and moderately fine textured soils on uplands, fans, and terraces on the island of Oahu. These soils are nearly level to very steep. They formed in old alluvium and material weathered from basic igneous rock. The association makes up about 15 percent of the island.

The elevation ranges from near sea level to 1,500 feet. Rainfall is fairly well distributed throughout the year. The annual amount is 40 to 90 inches. The mean annual soil temperature is between 70° and 73° F. The natural vegetation is guava, java plum, hilograss, and ricegrass.

Lolekaa soils make up 20 percent of the association and Waikane soils about 20 percent. Paumalu, Kemoo, Leilehua, Alaeloa, Kaneohe, Paaloa, Pohakupu, and Manana soils make up the rest.

Lolekaa soils have a surface layer of dark-brown silty clay and a dominantly silty clay subsoil. Their substratum is gravelly alluvium. Waikane soils have a surface layer of dark-brown silty clay and a subsoil of dark reddish-brown silty clay. Their substratum is gravelly alluvium.

This association is used mainly for pasture. Small areas are used for homesites, truck crops, and orchard crops. Areas of the minor soils in the association are used for sugarcane and pineapple. The potential for timber is high.

Island of Maui

Maui, the second largest island in the State, is 48 miles long and 26 miles wide. The land area is 465,920 acres, or 728 square miles. The island formed through the merging of two volcanoes—the East Maui volcano, or Haleakala, and the West Maui volcano. It is divided into three main areas—West Maui, East Maui, and Central Maui, or the isthmus.

West Maui is a deeply dissected volcano that rises to 5,788 feet at Puu Kukui. The central part of West Maui consists of canyons and steep ridges and is not easily accessible. It is surrounded by a moderately sloping, smooth narrow belt. There are a few gulches.

East Maui is dominated by the 10,025-foot Haleakala volcano. The volcano is dormant. The last eruption was about 1790 (*8*). Near the summit and on the eastern and southwestern slopes, the land is rough and rocky. The western and northern slopes are relatively smooth but are sloping to moderately steep.

Central Maui, the isthmus that connects West and East Maui, is smooth and nearly level. It is used mainly for sugarcane. Much of the isthmus is covered with alluvium.

Rainfall is heavy in the mountainous areas. Basal ground water occurs at the eastern end of East Maui and across the isthmus and along the coast of West Maui. Perched water also occurs on East Maui.

The business activity, the population, and the seat of government are centered in Wailuku and Kahului. Kahului has an airport and a deep-water harbor.

1. Pulehu-Ewa-Jaucas association

Deep, nearly level to moderately sloping, well-drained and excessively drained soils that have a moderately fine textured to coarse-textured subsoil or underlying material; on alluvial fans and in basins

This association consists of well-drained and excessively drained, medium-textured, moderately fine textured, and coarse-textured soils on alluvial fans and in basins on the island of Maui, mainly Central Maui. These soils are nearly level to moderately sloping. They developed in alluvium weathered from basic igneous rock, coral, and seashells. The association makes up about 4 percent of the island.

The elevation ranges from near sea level to 600 feet. The annual rainfall is 10 to 30 inches. The mean annual soil temperature is about 75° F. The natural vegetation is bermudagrass, bristly foxtailgrass, kiawe, and lantana.

Pulehu soils make up about 40 percent of the association, Ewa soils about 15 percent, and Jaucas soils 10 percent. Alae, Iao, Kealia, and Puuone soils make up the rest.

Pulehu soils have a surface layer of dark-brown, friable silt loam. Their substratum is dark-brown and dark yellowish-brown alluvium weathered from basic igneous rock. Ewa soils have a surface layer and subsoil of dark reddish-brown, friable silty clay loam. Their substratum is alluvium weathered from basic igneous rock. Jaucas soils have a pale-brown calcareous sand surface layer. Their substratum is yellowish-brown sand weathered from coral and seashells.

This association is used for sugarcane, truck crops, pasture, wildlife habitat, and homesites. Most of the sugarcane is grown on Ewa, Jaucas, and Pulehu soils. Upland game birds and native water birds are the principal kinds of wildlife.

2. Waiakoa-Keahua-Molokai association

Moderately deep and deep, nearly level to moderately steep, well-drained soils that have a moderately fine textured subsoil; on low uplands

This association consists of well-drained, moderately fine textured soils on low uplands on Central Maui. The

soils are nearly level to moderately steep. They formed in material weathered from basic igneous rocks. The association makes up about 15 percent of the island.

The elevation ranges from nearly sea level to 1,500 feet. The annual rainfall is 12 to 25 inches. The mean annual soil temperature is between 73° and 75° F. The natural vegetation is buffelgrass, feather fingergrass, guineagrass, ilima, kiawe, lantana, and uhaloa.

Waiakoa soils make up about 30 percent of the association, Keahua soils about 20 percent, and Molokai soils about 10 percent. The rest of the association consists of Alaeloa, Haliimaile, Kahana, Koele, Lahaina, Paia, Wahikuli, Wailuku, and Wainee soils.

Waiakoa soils have a surface layer of dark reddish-brown, friable silty clay loam. Their subsoil is dark reddish-brown and very dark grayish-brown, friable silty clay loam. They have a substratum of hard, basic igneous rock at a depth of 20 to 40 inches. Keahua soils have a surface layer of dark reddish-brown, friable silty clay loam. Their subsoil is dark reddish-brown, firm silty clay loam. The substratum is soft, weathered basic igneous rock. Molokai soils have a surface layer of dark reddish-brown, friable silty clay loam. Their subsoil is dark-red and dusky-red, friable silty clay loam and clay loam. The substratum is soft, weathered basic igneous rock.

This association is used for sugarcane, pineapple, pasture, wildlife habitat, and homesites. Upland game birds make up most of the wildlife population.

3. Honolua-Olelo association

Deep, gently sloping to moderately steep, well-drained soils that have a fine-textured subsoil; on intermediate uplands

This association consists of well-drained, fine-textured soils on the intermediate uplands of West Maui. These soils are gently sloping to moderately steep. They developed in material weathered from basic igneous rock. The association makes up about 1 percent of the island.

The elevation ranges from 500 to 3,500 feet. The annual rainfall is 30 to 80 inches. The mean annual soil temperature is between 67° and 71° F. The natural vegetation is guava, ferns, hilograss, koa, lantana, ohia lehua, and pukiawe.

Honolua soils make up about 40 percent of the association, and Olelo soils about 35 percent. Halawa, Naiwa, and Oli soils make up the rest.

Honolua soils have a surface layer of dark-brown, friable silty clay. Their subsoil is dark reddish-brown to reddish-brown, friable silty clay. Their substratum is soft, weathered basic igneous rock. Olelo soils have a surface layer of dark reddish-brown to dusky-red, friable silty clay, and their substratum is soft, weathered basic igneous rock.

This association is used for pineapple, pasture, woodland, wildlife habitat, and water supply. Olelo soils are used mainly for pasture, and Honolua soils for pineapple and woodland. Upland game birds make up most of the wildlife population.

4. Rock land-Rough mountainous land association

Very shallow, steep and very steep, rock land and rough mountain land

This association consists of very shallow soils on intermediate and high uplands on East and West Maui. These soils are steep and very steep. The association makes up about 41 percent of the island.

The elevation ranges from sea level to 10,000 feet. The annual rainfall is 20 to 150 inches. The natural vegetation on Rock land is kiawe, klu, piligrass, and ilima in the lower, drier areas and guava, pukiawe, and molassesgrass in the higher, wetter areas. Rough mountainous land is thickly vegetated with ferns, guava, hilograss, kukui, and ohia lehua.

Rock land makes up about 50 percent of the association and Rough mountainous land about 30 percent. Cinder land, Lava flows, Aa, Rock outcrop, Rough broken land, and Rough broken and stony land make up the rest.

Rock land consists of areas where rock outcrop covers 60 to 80 percent of the surface and the soil is 2 to 10 inches thick over bedrock. Rough mountainous land has very shallow soils, and local relief is generally more than 500 feet. There are many small streams throughout the area.

Upland game birds make up most of the wildlife population.

This association is used mainly for wildlife habitat and water supply. Small acreages of Rock land are used for pasture.

5. Puu Pa-Kula-Pane association

Deep, gently sloping to steep, well-drained soils that have a medium-textured or moderately fine textured subsoil or underlying material; on intermediate and high uplands

This general soil area consists of well-drained, medium-textured soils on intermediate and high uplands on East Maui. These soils are gently sloping to steep. They developed in material weathered from volcanic ash. The association makes up about 9 percent of the island.

The elevation ranges from 1,000 to 6,000 feet. The annual rainfall is 20 to 50 inches. The mean annual soil temperature is between 55° and 69° F. The natural vegetation is bermudagrass, black wattle, cactus, guineagrass, ilima, kikuyugrass, lantana, and rattailgrass.

Puu Pa soils make up about 35 percent of the association, Kula about 20 percent, and Pane soils about 10 percent. Io, Kaimu, Ulupalakua, and Uma soils make up the rest.

Puu Pa soils have a surface layer of very dark brown, very friable very stony silt loam. This layer is underlain by very dark grayish-brown and dark-brown, very friable silt loam. Cobblestone- and stone-size fragmental Aa lava is at a depth of 20 to 50 inches. Kula soils have a surface layer of dark reddish-brown, friable loam. The subsoil is dark reddish-brown, friable loam to silty clay loam. The substratum is weathered basic igneous rock. The depth to rock ranges from 24 to 60 inches. Pane soils have a surface layer of dark reddish-brown, very friable silt loam. The subsoil is dark reddish-brown, reddish-brown, and dark-brown, very friable silt loam and loam. The substratum is brown loam. It is 50 to 70 percent soft weathered rock fragments the size of gravel and cobblestones.

This association is used for truck crops, orchards, pasture, and wildlife habitat. Puu Pa and Pane soils are used mainly for pasture, and Kula soils for truck crops and orchards. Upland game birds are the main kinds of wildlife.

6. Hydrandepts-Tropaquods association

Gently sloping to steep, well-drained to poorly drained soils that have a moderately fine textured or fine textured subsoil; on intermediate and high uplands

This association consists of well-drained to poorly drained soils on the intermediate and high uplands of East and West Maui. These soils are gently sloping to steep. They developed in material weathered from volcanic ash, cinders, and basic igneous rock. The association makes up about 10 percent of the island.

The elevation ranges from 1,000 to 6,000 feet. The annual rainfall is 100 to 350 inches. The mean annual soil temperature is between 58° and 74° F. The natural vegetation is ape, clubmoss, eucalyptus, guava, koa, lapalapa, ohelo, ohia lehua, pamakani, ricegrass, false staghornfern, treefern, and sedges.

Hydrandepts make up about 60 percent of the association, and Tropaquods about 40 percent.

Hydrandepts are moderately well drained to well drained soils that have a surface layer high in organic-matter content. The subsoil is dark-brown or dark yellowish-brown silty clay loam or silty clay. Tropaquods are poorly drained soils that have a peaty and mucky surface layer and a mottled silty clay subsoil. The subsoil contains an ironstone sheet 1/4 to 1 inch thick. These soils are smeary and harden irreversibly.

This association is used for pasture, wildlife habitat, and water supply. Upland game birds are the principal kinds of wildlife.

7. Hana-Makaalae-Kailua association

Moderately deep and deep, gently sloping to steep, well-drained soils that have a moderately fine textured or fine textured subsoil or underlying material; on intermediate uplands

This association consists of well-drained, moderately fine textured and fine textured soils on the intermediate uplands of East Maui. These soils are gently sloping to steep. They developed in material weathered from volcanic ash. The association makes up about 7 percent of the island.

The elevation ranges from near sea level to 2,500 feet. The annual rainfall is 40 to 160 inches. The mean annual soil temperature is between 69° and 75° F. The natural vegetation is Christmas berry, ferns, guava, guineagrass, hilograss, kaimiclover, and kikuyugrass.

Hana soils make up about 30 percent of the association, Makaalae soils about 25 percent, and Kailua soils about 20 percent. Kaupo, Makawao, Malama, and Opihikao soils make up the rest.

Hana soils have a surface layer of very dark brown and very dark grayish-brown, friable silty clay loam. The subsoil is dark-brown, friable silty clay loam. The substratum is moderately weathered gravel-size cinders. Stone- and boulder-size fragmental Aa lava is at a depth of 34 to 48 inches. Makaalae soils have a surface layer of very dark-brown, firm silty clay. Below this is very dark grayish-brown, firm silty clay. Hard, stone- and boulder-size fragmental Aa lava is at a depth of 24 to 48 inches. Kailua soils have a surface layer of dark-brown, friable silty clay. The subsoil is dark-brown and dark reddish-brown, friable silty clay and silty clay loam. The substratum is soft, weathered basic igneous rock. The surface layer of Hana and Makaalae soils ranges from nonstony to extremely stony.

This association is used for pineapple, truck crops, orchards, pasture, woodland, wildlife habitat, homesites, and water supply. Hana, Kailua, and Makaalae soils are used mainly for pasture. Most of the pineapple, truck crops, and woodland is on Kailua soils. Wildlife consists mainly of upland game birds.

8. Pauwela-Haiku association

Deep, gently sloping to moderately steep, well-drained soils that have a fine textured subsoil; on low uplands

This association consists of well-drained, fine-textured soils on low uplands on the north-facing slopes of East Maui. These soils are gently sloping to moderately steep. They developed in material weathered from basic igneous rock. The association makes up about 3 percent of the island.

The elevation ranges from near sea level to 1,500 feet. The annual rainfall is 50 to 120 inches. The mean annual soil temperature is between 70° and 75° F. The natural vegetation is californiagrass, Christmas berry, guava, hilograss, and ricegrass.

Pauwela soils make up about 45 percent of the association and Haiku about 40 percent. Hamakuapoko soils make up the rest.

Pauwela soils have a surface layer of dark grayish-brown, firm clay. The subsoil is dark reddish-brown, firm clay. The substratum is soft, weathered basic igneous rock. Haiku soils have a surface layer of dark-brown, firm clay. The subsoil is yellowish-red, dark reddish-brown, and dark-red, friable clay and silty clay. The substratum is soft, weathered basic igneous rock. The surface layer of both soils has high bulk density because of the concentration of heavy minerals.

This association is used for pineapple, pasture, homesites, and water supply. Pauwela soils are used mainly for pasture. Only a small acreage is in pineapple. Most of the pineapple is grown on Haiku soils. Wildlife consists mainly of upland game birds.

9. Laumaia-Kaipoioi-Olinda association

Deep, gently sloping to very steep, well-drained soils that have a moderately fine textured or medium-textured subsoil; on intermediate and high uplands

This association consists of well-drained, medium-textured soils on the intermediate and high uplands of East Maui. These soils are gently sloping to very steep. They developed in material weathered from volcanic ash. The association makes up about 5 percent of the island.

The elevation ranges from 2,500 to 8,000 feet. The annual rainfall is 30 to 60 inches. The mean annual soil temperature is between 50° and 56° F. The natural vegetation is black wattle, eucalyptus, gosmore, kikuyugrass, pukiawe, sweet vernalgrass, white clover, and Yorkshire foggrass.

Laumaia soils make up about 45 percent of the association, Kaipoioi soils about 40 percent, and Olinda soils about 15 percent.

Laumaia soils have a surface layer of black, very friable loam. The subsoil is very dark brown, friable silty clay loam and silt loam. The substratum consists of

moderately consolidated bands of volcanic ash and cinders. Kaipoioi soils have a surface layer of black, very friable loam. The subsoil is black and very dark brown, very friable silt loam and silty clay loam. The substratum consists of layers of ash and cinders. Olinda soils have a surface layer of dark reddish-brown, friable loam. The subsoil is dark reddish-brown and yellowish-red, friable silty clay loam. The substratum is soft, weathered basic igneous rock. It occurs at a depth of 40 to 60 inches or more.

This association is used for truck crops, orchards, pasture, woodland, and wildlife habitat. Laumaia and Kaipoioi soils are used mainly for pasture. Most of the truck crops, the orchards, and the woodland is on Olinda soils. Upland game birds are the principal kinds of wildlife.

10. Keawakapu-Makena association

Gently sloping to moderately steep, well-drained soils that have a fine-textured to medium-textured subsoil and are shallow to deep over fragmental lava; on low uplands

This association consists of well-drained, medium-textured soils on the low uplands of East Maui. These soils are gently sloping to moderately steep. They developed in material weathered from volcanic ash. The association makes up about 2 percent of the island of Maui.

The elevation ranges from 100 to 800 feet. The annual rainfall is 10 to 20 inches. The mean annual soil temperature is about 75° F. The natural vegetation is feather fingergrass, ilima, kiawe, and uhaloa.

Keawakapu soils make up about 60 percent of the association, and Makena about 40 percent.

Keawakapu soils have a surface layer of dark reddish-brown, very friable extremely stony silt loam. The subsoil is dark reddish-brown, friable silty clay loam and silty clay. The substratum is cobblestone- and stone-size fragmental Aa lava. It is at a depth of 12 to 30 inches. Makena soils have a surface layer of very dark brown, very friable loam. The subsoil is very dark grayish-brown and yellowish-brown, very friable silt loam. The substratum is cobblestone- and stone-size fragmental Aa lava. It is at a depth of 40 to 60 inches.

This association is used for pasture and wildlife habitat. Wildlife consists of upland game birds.

11. Kamaole-Oanapuka association

Gently sloping to moderately steep, well-drained, very stony and extremely stony soils that have a fine-textured or medium-textured subsoil and are shallow to deep over fragmental lava; on low and intermediate uplands

This association consists of well-drained, very stony and extremely stony, moderately fine textured and medium-textured soils on the low and intermediate uplands of East Maui. These soils are gently sloping to moderately steep. They developed in material weathered from volcanic ash. The association makes up about 3 percent of the island.

The elevation ranges from 100 to 2,300 feet. The annual rainfall is 15 to 25 inches. The mean annual soil temperature is between 69° and 73° F. The natural vegetation is bermudagrass, feather fingergrass, ilima, kiawe, koa haole, lantana, and Natal redtop.

Kamaole soils make up about 55 percent of the association, and Oanapuka soils about 45 percent.

Kamaole soils have a surface layer of dark-brown and dark reddish-brown, friable silty clay loam. The subsoil is dark reddish-brown, firm silty clay. The substratum is cobblestone- and stone-size fragmental Aa lava. It is at a depth of 16 to 24 inches. Oanapuka soils have a surface layer of very dark brown and very dark grayish-brown very friable silt loam. The subsoil is very dark grayish-brown, friable silt loam. The substratum is cobblestone- and stone-size fragmental Aa lava. It is at a depth of 40 to 60 inches or more.

This association is used for pasture and wildlife. Wildlife consists mainly of upland game birds.

Islands of Molokai and Lanai

Molokai, the fifth largest island in the State, is 38 miles long and 10 miles wide. The land area is 166,400 acres, or 260 square miles. Molokai is divided into three main sections—West Molokai, East Molokai, and Central Molokai, or the Hoolehua Plain.

West Molokai makes up about 30 percent of the total area of the island. It rises to 1,380 feet above sea level. About 8,000 acres is cultivated to pineapple, and the rest is in pasture.

East Molokai makes up nearly half the total land area. It is mostly mountainous and has many gulches and canyons. The northern side is inaccessible. The highest point on the island is 4,970 feet, at Kamakou.

Central Molokai is relatively level and makes up about 20 percent of the total area. About 15,000 acres is deep stone-free soils, mostly in pineapple. The rest is stony and eroded and is used for pasture.

Along the northern coast of Molokai is a sheer cliff 3,000 feet high. At its base is the Kalaupapa Peninsula, which was formed from a volcanic eruption after the main part of the island formed. Along the southern coast is a narrow level strip that formed in marine and alluvial sediments.

The only perennial streams that reach the sea are on East Molokai. Most are on the windward side. Nearly all of the island is underlain by basal ground water. The water is fresh below most of East Molokai but brackish below West and Central Molokai. Fresh water is also confined between lava dikes at high elevations on East Molokai (*13*).

Kaunakakai, which is centrally located on the southern coast, is the principal town. It has a shallow-water harbor. There is an airport in Hoolehua.

Lanai, the sixth largest island in the State, is 18 miles long and 13 miles wide. The land area is 90,000 acres, or 141 square miles. The island rises to 3,370 feet at the Lanaihale summit. Southwest of the summit, at an elevation of 1,000 to 2,000 feet, is the Central Plateau of Lanai. On this plateau is the largest pineapple plantation in the world. Below the 1,200-foot elevation the soils are eroded and stony. The north end of Lanai, at an elevation of 1,500 to 1,800 feet, consists of broad areas of severely windblown soils. The north and east sides of the island are dissected by many deep gulches and are inaccessible in many places.

Because Lanai is located on the leeward side of West Maui, the rainfall is low. As a result, the recharge of ground water is slow. Norfolk Island pines are planted along the ridges near Lanaihale to improve the watershed. These trees collect fog drip, which supplements the 38 inches of annual rainfall. There are no perennial streams on Lanai. Domestic water and irrigation water are obtained from water confined between lava dikes at high elevations.

Nearly the entire population lives in Lanai City, the only town on the island. An airport is located nearby. Kaumalapau Harbor, a shallow-water harbor, is on the southwestern coast.

1. *Jaucas-Mala-Pulehu association*

Deep, nearly level and gently sloping, excessively drained and well-drained soils that have coarse-textured to fine-textured underlying material; on alluvial fans and in drainageways

This association occurs as a narrow band along the coastal plains on the islands of Molokai and Lanai. It consists of soils that formed in alluvium and coral sand and vary widely in texture and drainage. The soils are on alluvial fans and in drainageways. They are nearly level and gently sloping. The association makes up about 5 percent of the islands.

The elevation ranges from sea level to 250 feet. The annual rainfall is 10 to 40 inches. Most of the rain falls between November and April; there is very little rain during the summer. The mean annual soil temperature is between 73° and 75° F. The natural vegetation is kiawe, bristly foxtail, lantana, and bermudagrass.

Jaucas soils make up about 20 percent of the association, Mala soils 20 percent, and Pulehu soils 10 percent. Kealia, Kawaihapai, and Lualualei soils and areas of Stony alluvial land and Sandy alluvial land make up the rest.

Jaucas soils are excessively drained, pale-brown sandy soils that formed in coral sand. Mala and Pulehu soils are well drained. Mala soils are stratified with dark reddish-brown silty clay throughout the profile. Pulehu soils are dark colored and have a stratified sand to silty clay subsoil.

This association is used for alfalfa, pasture, truck crops, orchards, and wildlife habitat. Alfalfa is grown on the Mala soils. Truck crops and orchard crops are grown on Mala and Pulehu soils. Water for irrigation is obtained from wells 10 to 20 feet deep. The water in most places is brackish. For this reason, heavy applications of irrigation water are needed to prevent accumulation of salt in the soil. Most of the forage from buffelgrass and annual grasses is produced in winter and spring. In summer the main source of feed is kiawe pods. Deer, quail, pheasant, and dove are the principal kinds of wildlife.

2. *Molokai-Lahaina association*

Deep, nearly level to moderately steep, well-drained soils that have a moderately fine textured or fine textured subsoil; on uplands

This association consists of well-drained, fine textured and moderately fine textured soils on Central and West Molokai (fig. 2) and on the Central Plateau of Lanai. The soils occur as broad, nearly level areas and moderately steep slopes. They formed in material weathered from basic igneous rocks. The association makes up about 25 percent of the two islands.

The elevation ranges from 100 to 1,300 feet on Molokai and from 500 to 1,750 feet on Lanai. The annual rainfall amounts to 15 to 40 inches. Most of it falls between November and April; there is little rainfall in summer. The mean annual soil temperature is between 69° and 73° F. The natural vegetation is kiawe, ilima, uhaloa, and fingergrass.

Molokai soils make up about 35 percent of the association and Lahaina soils 15 percent. Hoolehua, Holomua, Uwala, Waihuna, and Waikapu soils make up the rest.

Molokai soils have a surface layer and subsoil of dark reddish-brown, friable silty clay loam. The substratum is soft weathered rock. Lahaina soils are similar to Molokai soils, except that the texture is dominantly silty clay.

This association is used for pineapple, pasture, truck crops, and wildlife habitat. Pineapple is the principal crop. At the higher elevations irrigation is not needed for pineapple; at the lower elevations it is needed during the dry season. Many kinds of truck crops can be grown on irrigated soils. Where irrigation water is not available, areas that are too dry for pineapple are used for pasture. Most of this association is subject to strong winds, and windbreaks are necessary. Deer, pheasant, quail, and francolin are the main kinds of wildlife.

3. *Kahanui-Kalae-Kanepuu association*

Deep, gently sloping to moderately steep, well-drained soils that have a dominantly fine-textured subsoil; on uplands

This association consists of well-drained, fine textured and moderately fine textured soils on uplands on the islands of Molokai and Lanai. These soils are gently sloping to moderately steep. They developed in volcanic ash and in material weathered from basic igneous rock. The association makes up about 5 percent of the islands.

The elevation ranges from 500 to 3,750 feet. The annual rainfall is 30 to 80 inches and is fairly well distributed throughout the year. The mean annual soil temperature is between 62° and 70° F. The natural vegetation is guava, hilograss, Christmas berry, and yellow foxtail. At the higher elevations ohia lehua, sweet vernal, and pukiawe are common.

Kahanui, Kalae, and Kanepuu soils each make up about 15 percent of the association. Halawa, Alaeloa, Naiwa, and Olelo soils and areas of Rough broken land make up the rest.

Soils in this association have high bulk density in the upper part of the profile because of the concentration of heavy minerals, such as iron and titanium oxides. Kahanui soils have a surface layer of dark-brown gravelly silty clay and a subsoil of dark yellowish-brown and dark-brown silty clay and clay. An ironstone sheet overlies soft weathered rock at a depth of about 22 inches. Kalae soils have a surface layer of dark reddish-brown silty clay and a subsoil of dark reddish-brown to dark-red silty clay to silt loam. Their substratum is soft weathered rock. Kanepuu soils have a surface layer and

Figure 2.—An area of the Molokai-Lahaina association on Central Molokai showing part of Molakai Irrigation Project. Pipeline is buried at a depth of 6 feet. This association is used extensively for pineapple.

subsoil of dark reddish-brown silty clay. Their substratum is soft weathered rock.

This association is used for pasture, wildlife habitat, woodland, and pineapple. Pastures respond well to fertilizer and lime. Deer and pheasant are the principal kinds of wildlife. Kahanui and Kalae soils are used for woodland. Pine and eucalyptus are the common timber species. Kalae soils are also used for pineapple.

4. Very stony land-Rock land association

Gently sloping to very steep, rocky and stony land types; on uplands and in gulches and valleys

This association consists of gently sloping to very steep, stony and rocky land on uplands and in gulches and valleys on the islands of Molokai and Lanai. The association makes up about 40 percent of the islands.

The elevation ranges from near sea level to 3,000 feet. The annual rainfall is dominantly 10 to 30 inches; most of it falls between November and April. The mean annual soil temperature is between 70° and 75° F. The natural vegetation is mainly kiawe, piligrass, Japanese tea, klu, and Natal redtop.

Very stony land, eroded, makes up about 35 percent of the association, Very stony land 25 percent, and Rock land 15 percent. Rock outcrop and Kalaupapa, Kapuhikani, and Pamoa soils make up the rest.

Very stony land, eroded, is 6 to 30 inches of dark reddish-brown soil material that has many stones and boulders on the surface. Very stony land is made up of many stones and boulders that overlie weathered rock. Rock land is in steep gulches, and 60 to 90 percent of its surface is covered with rock outcrops and stones.

This association is used for pasture and wildlife habitat. Forage from buffelgrass and piligrass is produced mainly during the rainy season. It is difficult to improve pastures because of the stones and rock outcrops. Deer, pheasant, quail, and francolin are the principal kinds of wildlife.

5. Rough broken land-Oli association

Shallow to deep, very steep to precipitous soils in gulches and moderately deep to deep, gently sloping to steep, well-drained soils that have a medium-textured and moderately fine textured subsoil; on uplands

This association consists of well-drained, medium-textured soils on the island of Molokai. It occurs on uplands that are dissected by gulches. The soils are gently sloping to very steep. They formed in volcanic ash and in material weathered from basic igneous rock. The association makes up about 5 percent of the islands.

The elevation ranges from near sea level to 3,500 feet. The annual rainfall is 30 to 50 inches; most of it falls between November and April. The mean annual soil temperature is between 68° and 72° F. The natural vegetation is guava, Natal redtop, lantana, bermudagrass, molassesgrass, aalii, and pukiawe.

Rough broken land makes up 70 percent of the association, and Oli soils 30 percent.

Rough broken land is in gulches. It consists of soft weathered rock covered in places with a thin layer of soil. Oli soils are dark brown throughout the profile. The surface layer and the upper part of the subsoil are very friable silt loam, and the lower part of the subsoil is friable clay loam. Bedrock is at a depth of 2 to 4 feet.

This association is used mainly for pasture and wildlife habitat. A small acreage is used for woodland. Deer, pheasant, and francolin are the principal kinds of wildlife.

6. *Rough mountainous land-Amalu-Olokui association*

Shallow, very steep lands of mountains and gulches and deep to shallow, gently sloping to hilly, poorly drained soils over soft weathered rock; on uplands

This association consists of very steep gulches and valleys and gently sloping to hilly, poorly drained upland soils. It occurs on the islands of Molokai and Lanai. The soils formed in material weathered from basic igneous rock and are high in organic-matter content. This association makes up about 20 percent of the islands.

The elevation ranges from near sea level to 5,000 feet. The annual rainfall ranges from 75 to more than 150 inches and is fairly well distributed throughout the year. The mean annual soil temperature is between 58° and 68° F. The natural vegetation is of the rain forest type. It consists of treefern, ohia lehua, false staghornfern, lapalapa, and sedges.

Rough mountainous land makes up about 80 percent of the association, and Amalu and Olokui soils 10 percent. Tropaquods make up the rest.

Rough mountainous land is on the walls of valleys and gulches. Slopes are steeper than 60 percent. The soil material is shallow, and there are rock outcrops, waterfalls, and occasional scars caused by soil slippage. Amalu soils have 6 to 15 inches of peat and muck over about 10 inches of dark-gray silty clay. An ironstone sheet about an inch thick lies below the silty clay and overlies soft weathered rock. Olokui soils are similar to Amalu soils but have 4 inches or less of peat and muck.

This association is used for watershed and wildlife habitat. The potential for woodland is low because of the very steep slopes and the lack of a timber species suited to the shallow, poorly drained soils. The heavy rainfall is an important factor in recharging the supply of ground water. The kinds of wildlife on Lanai are deer and wild goats, and on Molokai, deer, wild goats, and wild pigs.

Descriptions of the Soils

In this section the soil series and mapping units of the five islands in this survey area are described. The approximate acreage and proportionate extent of the soils are given in table 1.

Three kinds of mapping units are described. A high- and medium-intensity survey was made of all cultivated areas; a low-intensity survey was made of all grazing and forested lands; and a reconnaissance survey was made of inaccessible areas. The composition of the low-intensity mapping units is more variable than that of the high- and medium-intensity units, but it has been controlled well enough to allow interpretations for the expected uses of the soils.

The series descriptions are in alphabetic order. Following each series description is a fairly detailed description of one mapping unit of the series. This detailed description is followed by brief descriptions of the rest of the mapping units.

In the first mapping unit of each series is a short narrative description of a profile representative of the series. Following this is a much more detailed description of the same profile, which can be used by scientists, engineers, and others in making highly technical interpretations. Unless otherwise stated, the color names and color symbols given are for moist soils.

Following the name of each mapping unit is a symbol in parentheses. This symbol identifies the mapping unit on the detailed soil map and indicates whether it is within the high- and medium-intensity, low-intensity, or reconnaissance survey. For a soil within the high- and medium-intensity survey, the symbol consists of a combination of capital and lower-case letters (AeE). It includes a number if the soil is eroded (HfD2). For a soil within the low-intensity survey, the symbol consists of capital letters (ALF). For a soil within the reconnaissance survey, the symbol consists of a lower-case "r" preceding the capital letters (rAAE).

Listed at the end of the description of each mapping unit are the capability classification, sugarcane group, pineapple group, pasture group, and woodland group in which the soil has been placed.

Technical terms used for describing the soils are defined in the Soil Survey Manual (*16*) and in the Glossary. For more general information about the soils, the reader can refer to the section "General Soil Map," in which the broad patterns of soils are described.

Alae Series

This series consists of excessively drained soils on alluvial fans on the island of Maui. These soils developed in volcanic ash and recent alluvium derived from basic igneous rock. They are nearly level to gently sloping. Most areas have cobblestones on the surface. Elevations range from 50 to 600 feet. The annual rainfall amounts to 12 to 20 inches. The mean annual soil temperature is 74° F. Alae soils are geographically associated with Ewa, Pulehu, and Waiakoa soils.

These soils are used for sugarcane and pasture. Small areas are used for truck crops. The natural vegetation is feather fingergrass, kiawe, and uhaloa.

Alae cobbly sandy loam, 0 to 3 percent slopes (AcA).—This soil occurs on smooth alluvial fans. Included in mapping were small areas of Ewa and Pulehu soils.

In a representative profile the surface layer, about 7 inches thick, is very dark grayish-brown, cobbly sandy loam that has granular structure. The substratum, to a depth of 48 inches or more, is very dark grayish-brown, very dark gray, and grayish-brown sandy loam and coarse and very coarse sand. The soil is neutral or mildly alkaline in the surface layer and mildly to moderately alkaline in the substratum.

Permeability is rapid. Runoff is slow, and the erosion hazard is no more than slight. The available water capac-

TABLE 1.—*Approximate acreage and proportionate extent of the soils*

HIGH-INTENSITY AND MEDIUM-INTENSITY SURVEY

Soil	Kauai		Oahu		Maui		Molokai		Lanai	
	Acres	*Percent*	*Acres*	*Percent*	*Acres*	*Percent*	*Acres*	*Percent*	*Acres*	*Percent*
Alae sandy loam, 3 to 7 percent slopes					972	0.20				
Alae cobbly sandy loam, 0 to 3 percent slopes					783	.16				
Alae cobbly sandy loam, 3 to 7 percent slopes					290	.06				
Alaeloa silty clay, 3 to 7 percent slopes					555	.11				
Alaeloa silty clay, 7 to 15 percent slopes					1,290	.27				
Alaeloa silty clay, 15 to 35 percent slopes			1,532	0.39	994	.21	836	0.50		
Ewa silty clay loam, 0 to 3 percent slopes					3,760	.80				
Ewa silty clay loam, 3 to 6 percent slopes			984	.25						
Ewa silty clay loam, 6 to 12 percent slopes			699	.18						
Ewa cobbly silty clay loam, 0 to 3 percent slopes					506	.10				
Ewa cobbly silty clay loam, 3 to 7 percent slopes					306	.06				
Ewa silty clay loam, moderately shallow, 0 to 2 percent slopes			2,575	.66						
Ewa silty clay loam, moderately shallow, 2 to 6 percent slopes			262	.06						
Ewa silty clay, 0 to 3 percent slopes					366	.07				
Ewa silty clay, 3 to 7 percent slopes					230	.04				
Ewa cobbly silty clay, 3 to 7 percent slopes					297	.06				
Ewa stony silty clay, 0 to 2 percent slopes			344	.08						
Ewa stony silty clay, 2 to 6 percent slopes			265	.06						
Ewa stony silty clay, 6 to 12 percent slopes			1,359	.35						
Fill land	1,458	0.41	1,546	.39	240	.05				
Haiku silty clay, 3 to 7 percent slopes					836	.17				
Haiku silty clay, 7 to 15 percent slopes					226	.04				
Haiku clay, 3 to 7 percent slopes					1,169	.25				
Haiku clay, 7 to 15 percent slopes					2,950	.63				
Haleiwa silty clay loam, 0 to 10 percent slopes							171	.10		
Haleiwa very stony silty clay loam, 0 to 15 percent slopes							351	.21		
Haleiwa silty clay, 0 to 2 percent slopes			1,902	.49						
Haleiwa silty clay, 2 to 6 percent slopes			474	.12						
Halii gravelly silty clay, 3 to 8 percent slopes	2,213	.62								
Halii gravelly silty clay, 8 to 15 percent slopes	1,110	.31								
Halii gravelly silty clay, 15 to 25 percent slopes, eroded	639	.18								
Halii gravelly silty clay, 25 to 40 percent slopes, eroded	897	.25								
Haliimaile silty clay loam, 3 to 7 percent slopes					578	.12				
Haliimaile silty clay loam, 7 to 15 percent slopes					1,782	.38				
Haliimaile silty clay, 3 to 7 percent slopes					2,693	.57				
Haliimaile silty clay, 7 to 15 percent slopes					1,309	.28				
Haliimaile gravelly silty clay, 7 to 15 percent slopes, eroded					218	.04				
Hamakuapoko silty clay, 3 to 7 percent slopes					968	.20				
Hamakuapoko silty clay, 7 to 15 percent slopes					244	.05				
Hamakuapoko silty clay, 7 to 15 percent slopes, eroded					264	.05				
Hanalei silty clay loam, 0 to 2 percent slopes	273	.07								
Hanalei silty clay, 0 to 2 percent slopes	2,752	.77	2,034	.52						
Hanalei silty clay, 2 to 6 percent slopes			1,183	.30						
Hanalei stony silty clay, 2 to 6 percent slopes			707	.18						

TABLE 1.—*Approximate acreage and proportionate extent of the soils*—Continued

HIGH-INTENSITY AND MEDIUM-INTENSITY SURVEY—Continued

Soil	Kauai		Oahu		Maui		Molokai		Lanai	
	Acres	*Percent*	*Acres*	*Percent*	*Acres*	*Percent*	*Acres*	*Percent*	*Acres*	*Percent*
Hanalei peaty silty clay loam, 0 to 2 percent slopes	300	0.08								
Hanalei silty clay, deep water table, 0 to 6 percent slopes	1,500	.42								
Hanamaulu silty clay, 3 to 8 percent slopes	2,854	.80								
Hanamaulu silty clay, 8 to 15 percent slopes	1,077	.30								
Hanamaulu silty clay, 15 to 25 percent slopes	795	.22								
Hanamaulu silty clay, 25 to 40 percent slopes	890	.25								
Hanamaulu stony silty clay, 10 to 35 percent slopes	1,307	.36								
Hanamaulu bouldery silty clay, 10 to 35 percent slopes	854	.24								
Holomua silt loam, 0 to 3 percent slopes							1,445	.86		
Holomua silt loam, 3 to 7 percent slopes							2,425	1.45		
Holomua silt loam, 3 to 7 percent slopes, severely eroded							1,424	.85		
Holomua silt loam, 7 to 15 percent slopes							482	.28		
Holomua silt loam, 7 to 15 percent slopes, severely eroded							943	.56		
Honolua silty clay, 7 to 15 percent slopes					1,659	.35				
Honolua silty clay, 15 to 25 percent slopes					911	.19				
Honouliuli clay, 0 to 2 percent slopes			3,278	.84						
Honouliuli clay, 2 to 6 percent slopes			235	.06						
Hoolehua silty clay loam, 3 to 10 percent slopes, severely eroded							1,700	1.02		
Hoolehua silty clay, 0 to 3 percent slopes							441	.26		
Hoolehua silty clay, 3 to 7 percent slopes							1,936	1.16		
Hoolehua silty clay, 7 to 15 percent slopes							3,687	2.21		
Hoolehua silty clay, 15 to 35 percent slopes							600	.36		
Iao silty clay, 0 to 3 percent slopes					458	.09				
Iao silty clay, 3 to 7 percent slopes					397	.08				
Iao cobbly silty clay, 3 to 7 percent slopes					612	.13				
Iao cobbly silty clay, 7 to 15 percent slopes					330	.07				
Iao clay, 3 to 7 percent slopes					1,210	.25				
Iao clay, 7 to 15 percent slopes					341	.07				
Ioleau silty clay loam, 2 to 6 percent slopes	972	.27								
Ioleau silty clay loam, 6 to 12 percent slopes	1,334	.37								
Ioleau silty clay loam, 12 to 20 percent slopes, eroded	1,008	.28								
Ioleau silty clay loam, 20 to 35 percent slopes, eroded	979	.27								
Jaucas sand, 0 to 15 percent slopes			4,795	1.24	2,923	.62	1,073	.64	781	.86
Jaucas sand, saline, 0 to 12 percent slopes			213	.05	737	.15				
Jaucas loamy fine sand, 0 to 8 percent slopes	3,562	1.00								
Jaucas loamy fine sand, dark variant, 0 to 8 percent slopes	377	.10								
Kaena clay, 2 to 6 percent slopes			790	.20						
Kaena clay, 6 to 12 percent slopes			326	.08						
Kaena stony clay, 2 to 6 percent slopes			308	.07						
Kaena stony clay, 6 to 12 percent slopes			251	.08						
Kaena stony clay, 12 to 20 percent slopes			561	.14						
Kaena very stony clay, 10 to 35 percent slopes			1,923	.49						
Kaena clay, brown variant, 1 to 6 percent slopes	430	.12								
Kaena clay, brown variant, 6 to 12 percent slopes	376	.10								
Kahana silty clay, 3 to 7 percent slopes					734	.15				

TABLE 1.—*Approximate acreage and proportionate extent of the soils*—Continued

HIGH-INTENSITY AND MEDIUM-INTENSITY SURVEY—Continued

Soil	Kauai		Oahu		Maui		Molokai		Lanai	
	Acres	*Percent*	*Acres*	*Percent*	*Acres*	*Percent*	*Acres*	*Percent*	*Acres*	*Percent*
Kahana silty clay, 7 to 15 percent slopes					1, 562	0. 33				
Kahana silty clay, 15 to 25 percent slopes					390	. 08				
Kalae silty clay, 2 to 7 percent slopes							548	. 32	766	. 85
Kalae silty clay, 7 to 15 percent slopes							103	. 06	407	. 45
Kalae silty clay, 5 to 15 percent slopes, severely eroded							670	. 40		
Kalae silty clay, 15 to 25 percent slopes, severely eroded							100	. 06	108	. 12
Kalae silty clay, 25 to 40 percent slopes, severely eroded							173	. 10		
Kalapa silty clay, 8 to 20 percent slopes	230	. 06								
Kalapa silty clay, 20 to 40 percent slopes	869	. 24								
Kalapa silty clay, 40 to 70 percent slopes	4, 050	1. 14								
Kalihi clay	334	. 09								
Kaloko clay loam	200	. 05								
Kaloko clay	792	. 22	314	. 08						
Kaloko clay, noncalcareous variant			363	. 09						
Kaneohe silty clay, 3 to 8 percent slopes			291	. 07						
Kaneohe silty clay, 8 to 15 percent slopes			305	. 07						
Kanepuu silty clay, 3 to 7 percent slopes									987	1. 09
Kanepuu silty clay, 3 to 7 percent slopes, eroded									661	. 73
Kanepuu silty clay, 7 to 15 percent slopes									263	. 29
Kanepuu silty clay, 7 to 15 percent slopes, eroded									600	. 66
Kapaa silty clay, 3 to 8 percent slopes	5, 663	1. 59								
Kapaa silty clay, 8 to 15 percent slopes	2, 308	. 65								
Kapaa silty clay, 15 to 25 percent slopes	1, 314	. 37								
Kapaa silty clay, 25 to 40 percent slopes	1, 307	. 36								
Kawaihapai clay loam, 0 to 2 percent slopes			1, 443	. 37			348	. 20		
Kawaihapai clay loam, 2 to 6 percent slopes			1, 183	. 30						
Kawaihapai clay loam, 6 to 15 percent slopes			248	. 06						
Kawaihapai stony clay loam, 0 to 2 percent slopes			365	. 09						
Kawaihapai stony clay loam, 2 to 6 percent slopes			1, 938	. 50			316	. 18		
Kawaihapai very stony clay loam, 0 to 15 percent slopes			1, 195	. 30			226	. 14		
Kawaihapai silty clay loam, 2 to 7 percent slopes							317	. 19		
Keaau clay, 0 to 2 percent slopes			828	. 21						
Keaau stony clay, 2 to 6 percent slopes			248	. 06						
Keaau clay, saline, 0 to 2 percent slopes			389	. 10						
Keahua silty clay loam, 3 to 7 percent slopes					3, 898	. 83				
Keahua silty clay loam, 7 to 15 percent slopes					1, 866	. 40				
Keahua cobbly silty clay loam, 3 to 7 percent slopes					1, 619	. 34				
Keahua cobbly silty clay loam, 7 to 15 percent slopes					2, 115	. 45				
Keahua cobbly silty clay loam, 15 to 25 percent slopes					817	. 17				
Keahua very stony silty clay loam, 7 to 25 percent slopes					1, 097	. 23				
Keahua silty clay, 7 to 15 percent slopes					822	. 17				
Keahua cobbly silty clay, 7 to 15 percent slopes					678	. 14				
Keahua stony silty clay, 7 to 15 percent slopes					340	. 07				
Kekaha silty clay, 0 to 2 percent slopes	1, 432	. 40								
Kekaha silty clay, 2 to 6 percent slopes	251	. 07								
Kekaha clay, 0 to 2 percent slopes	1, 361	. 38								

TABLE 1.—*Approximate acreage and proportionate extent of the soils*—Continued

HIGH-INTENSITY AND MEDIUM-INTENSITY SURVEY—Continued

Soil	Kauai		Oahu		Maui		Molokai		Lanai	
	Acres	*Percent*	*Acres*	*Percent*	*Acres*	*Percent*	*Acres*	*Percent*	*Acres*	*Percent*
Kemoo silty clay, 2 to 6 percent slopes			229	0.05						
Kemoo silty clay, 6 to 12 percent slopes			361	.09						
Kemoo silty clay, 12 to 20 percent slopes			956	.24						
Kemoo silty clay, 20 to 35 percent slopes			938	.24						
Kemoo silty clay, 35 to 70 percent slopes			3,393	.87						
Koele silty clay loam, 3 to 7 percent slopes									408	.45
Koele silty clay loam, 7 to 15 percent slopes									1,091	1.21
Koele silty clay loam, 15 to 25 percent slopes									222	.24
Koko silt loam, 2 to 6 percent slopes			996	.25						
Koko silt loam, 6 to 12 percent slopes			243	.06						
Koko silt loam, 12 to 25 percent slopes			214	.05						
Kokokahi clay, 6 to 12 percent slopes			709	.18						
Kolekole silty clay loam, 1 to 6 percent slopes			1,231	.31						
Kolekole silty clay loam, 6 to 12 percent slopes			794	.20						
Kolekole silty clay loam, 12 to 25 percent slopes			1,053	.27						
Koloa stony silty clay, 3 to 8 percent slopes	1,123	.31								
Koloa stony silty clay, 8 to 15 percent slopes	267	.07								
Koloa stony silty clay, 15 to 25 percent slopes	539	.15								
Kolokolo clay loam	619	.17								
Kula loam, 4 to 12 percent slopes					248	.05				
Kula loam, 12 to 20 percent slopes					2,876	.61				
Kula cobbly loam, 12 to 20 percent slopes					3,956	.84				
Kula very rocky loam, 12 to 40 percent slopes					1,770	.37				
Kunia silty clay, 0 to 3 percent slopes			3,848	.99						
Kunia silty clay, 3 to 8 percent slopes			2,085	.53						
Kunia silty clay, 8 to 15 percent slopes			666	.17						
Lahaina silty clay, 0 to 3 percent slopes			637	.16			560	.33	703	.78
Lahaina silty clay, 3 to 7 percent slopes			3,852	.99	1,373	.29	2,045	1.22	1,376	1.52
Lahaina silty clay, 3 to 7 percent slopes, severely eroded									490	.54
Lahaina silty clay, 7 to 15 percent slopes			2,524	.65	1,512	.32	1,619	.97	769	.85
Lahaina silty clay, 7 to 15 percent slopes, severely eroded			1,239	.32			904	.54	614	.68
Lahaina silty clay, 15 to 25 percent slopes					569	.12				
Lahaina silty clay, 15 to 25 percent slopes, severely eroded							408	.24	376	.41
Lahaina silty clay, 25 to 40 percent slopes, severely eroded							452	.27	79	.08
Lawai silty clay, 0 to 8 percent slopes	781	.22								
Lawai silty clay, 8 to 15 percent slopes	513	.14								
Lawai silty clay, 15 to 25 percent slopes	345	.09								
Leilehua silty clay, 2 to 6 percent slopes			3,687	.95						
Leilehua silty clay, 6 to 12 percent slopes			1,043	.26						
Lihue silty clay, 0 to 8 percent slopes	9,521	2.68								
Lihue silty clay, 8 to 15 percent slopes	2,658	.74								
Lihue silty clay, 15 to 25 percent slopes	1,076	.30								
Lihue silty clay, 25 to 40 percent slopes, eroded	1,024	.28								
Lihue gravelly silty clay, 0 to 8 percent slopes	961	.27								
Lihue gravelly silty clay, 8 to 15 percent slopes	315	.08								
Lolekaa silty clay, 3 to 8 percent slopes			2,569	.66						
Lolekaa silty clay, 8 to 15 percent slopes			923	.23						
Lolekaa silty clay, 15 to 25 percent slopes			1,689	.43						
Lolekaa silty clay, 25 to 40 percent slopes			2,636	.68						
Lolekaa silty clay, 40 to 70 percent slopes			3,199	.82						
Lualualei clay, 0 to 2 percent slopes	431	.12	1,766	.45			278	.16	45	.05
Lualualei clay, 2 to 6 percent slopes	579	.16	805	.20						
Lualualei stony clay, 0 to 2 percent slopes			964	.24						

TABLE 1.—*Approximate acreage and proportionate extent of the soils*—Continued

HIGH-INTENSITY AND MEDIUM-INTENSITY SURVEY—Continued

Soil	Kauai		Oahu		Maui		Molokai		Lanai	
	Acres	*Percent*	*Acres*	*Percent*	*Acres*	*Percent*	*Acres*	*Percent*	*Acres*	*Percent*
Lualualei stony clay, 2 to 6 percent slopes			1, 413	0. 36						
Mahana silt loam, 6 to 12 percent slopes	482	. 13								
Mahana silt loam, 12 to 20 percent slopes	1, 557	. 43								
Mahana silt loam, 12 to 20 percent slopes severely eroded	755	. 21								
Mahana silt loam, 20 to 35 percent slopes	1, 104	. 31								
Mahana silt loam, 20 to 35 percent slopes, severely eroded	1, 864	. 52								
Mahana silty clay loam, 6 to 12 percent slopes, eroded			690	. 17						
Mahana silty clay loam, 12 to 20 percent slopes, eroded			883	. 22						
Mahana silty clay loam, 20 to 35 percent slopes, eroded			1, 142	. 29						
Makalapa clay, 2 to 6 percent slopes			1, 992	. 51						
Makalapa clay, 6 to 12 percent slopes			703	. 18						
Makalapa clay, 12 to 20 percent slopes			248	. 06						
Makapili silty clay, 0 to 8 percent slopes	1, 401	. 39								
Makapili silty clay, 8 to 15 percent slopes	295	. 08								
Makapili silty clay, 15 to 25 percent slopes	339	. 09								
Makapili silty clay, 25 to 40 percent slopes	342	. 09								
Makawao silty clay, 3 to 7 percent slopes					410	. 08				
Makawao silty clay, 7 to 15 percent slopes					1, 488	. 31				
Makaweli silty clay loam, 0 to 6 percent slopes	3, 435	. 96								
Makaweli silty clay loam, 6 to 12 percent slopes	3, 367	. 94								
Makaweli silty clay loam, 12 to 20 percent slopes	2, 004	. 56								
Makaweli silty clay loam, 20 to 35 percent slopes, eroded	732	. 20								
Makaweli stony silty clay loam, 0 to 6 percent slopes	1, 749	. 49								
Makaweli stony silty clay loam, 6 to 12 percent slopes	956	. 26								
Makaweli stony silty clay loam, 12 to 20 percent slopes	707	. 19								
Makaweli stony silty clay loam, 20 to 35 percent slopes	491	. 13								
Makiki clay loam, 0 to 2 percent slopes			875	. 22						
Makiki stony clay loam, 0 to 3 percent slopes			537	. 13						
Mala silty clay, 0 to 3 percent slopes							1, 872	1. 12	191	. 21
Mala silty clay, 3 to 7 percent slopes							200	. 12	118	. 13
Mamala stony silty clay loam, 0 to 12 percent slopes	493	. 13	6, 293	1. 63						
Manana silty clay loam, 2 to 6 percent slopes			802	. 20						
Manana silty clay loam, 6 to 12 percent slopes			786	. 20						
Manana silty clay loam, 12 to 25 percent slopes, eroded			751	. 19						
Manana silty clay, 3 to 8 percent slopes			638	. 16						
Manana silty clay, 8 to 15 percent slopes			1, 001	. 25						
Manana silty clay, 15 to 25 percent slopes			229	. 05						
Manana silty clay, 12 to 25 percent slopes, eroded			354	. 09						
Manana silty clay, 25 to 40 percent slopes			694	. 17						
Mokuleia fine sandy loam	1, 639	. 46								
Mokuleia loam			524	. 13						
Mokuleia clay loam			655	. 16						
Mokuleia clay loam, poorly drained variant	1, 131	. 31								
Mokuleia clay			674	. 17						
Molokai silty clay loam, 0 to 3 percent slopes			280	. 07	1, 652	. 35	1, 955	1. 17	1, 652	1. 83

TABLE 1.—*Approximate acreage and proportionate extent of the soils*—Continued

HIGH-INTENSITY AND MEDIUM-INTENSITY SURVEY—Continued

Soil	Kauai		Oahu		Maui		Molokai		Lanai	
	Acres	*Percent*	*Acres*	*Percent*	*Acres*	*Percent*	*Acres*	*Percent*	*Acres*	*Percent*
Molokai silty clay loam, 3 to 7 percent slopes			3,715	0.96	4,438	0.95	6,939	4.17	4,439	4.93
Molokai silty clay loam, 3 to 7 percent slopes, severely eroded							605	.36		
Molokai silty clay loam, 7 to 15 percent slopes			1,519	.39	282	.06	2,925	1.75	522	.58
Molokai silty clay loam, 7 to 15 percent slopes, severely eroded							1,865	1.12	1,362	1.51
Molokai silty clay loam, 15 to 25 percent slopes			771	.19						
Molokai silty clay loam, shallow variant, 15 to 25 percent slopes, severely eroded							1,055	.63	372	.41
Niu silty clay loam, 6 to 12 percent slopes	800	.22								
Niu silty clay loam, 12 to 20 percent slopes	1,440	.40								
Niu silty clay loam, 6 to 20 percent slopes, eroded	234	.06								
Niu silty clay loam, 20 to 35 percent slopes, eroded	903	.25								
Nohili clay	1,150	.32								
Nonopahu clay, 2 to 10 percent slopes	651	.18								
Nonopahu stony clay, 2 to 12 percent slopes	247	.06								
Oli loam, 12 to 20 percent slopes	596	.16								
Paaloa silty clay, 3 to 12 percent slopes			2,625	.67						
Paaloa clay, 2 to 12 percent slopes			690	.17						
Paia silty clay, 3 to 7 percent slopes					4,293	.92				
Paia silty clay, 7 to 15 percent slopes					1,148	.24				
Paia silty clay, 7 to 15 percent slopes, eroded					214	.04				
Pakala clay loam, 0 to 2 percent slopes	937	.26								
Pakala clay loam, 2 to 10 percent slopes	235	.06								
Paumalu silty clay, 3 to 8 percent slopes			347	.08						
Paumalu silty clay, 8 to 15 percent slopes			480	.12						
Paumalu silty clay, 15 to 25 percent slopes			637	.16						
Paumalu silty clay, 25 to 40 percent slopes			546	.14						
Paumalu silty clay, 40 to 70 percent slopes			632	.16						
Pauwela clay, 3 to 7 percent slopes					782	.16				
Pauwela clay, 7 to 15 percent slopes					3,285	.70				
Pauwela clay, 15 to 25 percent slopes					1,673	.35				
Pearl Harbor clay			1,952	.50						
Pohakupu silty clay loam, 0 to 8 percent slopes	487	.13	626	.16						
Pohakupu silty clay loam, 8 to 15 per-percent slopes			238	.06						
Pooku silty clay loam, 3 to 8 percent slopes	775	.21								
Pooku silty clay loam, 8 to 25 percent slopes	321	.09								
Pooku silty clay, 0 to 8 percent slopes	2,058	.57								
Pooku silty clay, 8 to 15 percent slopes	1,556	.43								
Pooku silty clay, 15 to 25 percent slopes	1,053	.29								
Pooku silty clay, 25 to 40 percent slopes	2,024	.57								
Puhi silty clay loam, 0 to 3 percent slopes	442	.12								
Puhi silty clay loam, 3 to 8 percent slopes	7,078	1.99								
Puhi silty clay loam, 8 to 15 percent slopes	2,095	.59								
Puhi silty clay loam, 15 to 25 percent slopes	1,345	.37								
Puhi silty clay loam, 25 to 40 percent slopes	1,891	.53								
Pulehu sandy loam, 2 to 6 percent slopes							94	.05	199	.22
Pulehu stony sandy loam, 0 to 7 percent slopes							91	.05	101	.11
Pulehu silt loam, 0 to 3 percent slopes					2,329	.49				
Pulehu silt loam, 3 to 7 percent slopes					796	.17				

TABLE 1.—*Approximate acreage and proportionate extent of the soils*—Continued

HIGH-INTENSITY AND MEDIUM-INTENSITY SURVEY—Continued

Soil	Kauai		Oahu		Maui		Molokai		Lanai	
	Acres	*Percent*	*Acres*	*Percent*	*Acres*	*Percent*	*Acres*	*Percent*	*Acres*	*Percent*
Pulehu cobbly silt loam, 0 to 3 percent slopes					816	0.17				
Pulehu cobbly silt loam, 3 to 7 percent slopes					735	.15				
Pulehu clay loam, 0 to 3 percent slopes			1,112	.29	1,925	.41	339	.20	207	.23
Pulehu cobbly clay loam, 0 to 3 percent slopes					1,144	.24				
Pulehu cobbly clay loam, 3 to 7 percnet slopes					966	.20				
Pulehu stony clay loam, 2 to 6 percent slopes			443	.11						
Pulehu very stony clay loam, 0 to 12 percent slopes			914	.23						
Puu Opae silty clay loam, 8 to 15 percent slopes	847	.23								
Puu Opae silty clay loam, 15 to 25 percent slopes	1,355	.38								
Puu Opae silty clay loam, 25 to 40 percent slopes	1,447	.40								
Uwala silty clay loam, 2 to 7 percent slopes									1,632	1.81
Uwala silty clay loam, 7 to 15 percent slopes									1,164	1.29
Uwala silty clay loam, 7 to 15 percent slopes, severely eroded									1,173	1.30
Wahiawa silty clay, 0 to 3 percent slopes			8,981	2.32						
Wahiawa silty clay, 3 to 8 percent slopes			10,188	2.63						
Wahiawa silty clay, 8 to 15 percent slopes			1,740	.45						
Wahiawa silty clay, 15 to 25 percent slopes, eroded			241	.06						
Wahikuli silty clay, 3 to 7 percent slopes					354	.07				
Wahikuli stony silty clay, 3 to 7 percent slopes					441	.09				
Wahikuli stony silty clay, 7 to 15 percent slopes					894	.19				
Wahikuli very stony silty clay, 3 to 7 percent slopes					417	.08				
Waiakoa silty clay loam, 3 to 7 percent slopes					2,103	.45				
Waiakoa silty clay loam, 7 to 15 percent slopes					373	.08				
Waiakoa cobbly silty clay loam, 3 to 7 percent slopes					1,282	.27				
Waiakoa very stony silty clay loam, 3 to 7 percent slopes					2,003	.42				
Waiakoa very stony silty clay loam, 7 to 15 percent slopes					990	.21				
Waiakoa extremely stony silty clay loam, 3 to 7 percent slopes					344	.07				
Waiakoa extremely stony silty clay loam, 7 to 15 percent slopes					375	.08				
Waialua silty clay, 0 to 3 percent slopes			2,644	.68						
Waialua silty clay, 3 to 8 percent slopes			643	.16						
Waialua stony silty clay, 3 to 8 percent slopes			1,040	.26						
Waialua stony silty clay, 12 to 30 percent slopes			238	.06						
Waialua very stony silty clay, 12 to 20 percent slopes			268	.06						
Waialua clay, 2 to 6 percent slopes			512	.13						
Waihuna clay, 0 to 3 percent slopes									1,764	1.96
Waihuna clay, 3 to 7 percent slopes							177	.10	1,206	1.34
Waihuna clay, 7 to 15 percent slopes							476	.28	298	.33
Waihuna clay, 15 to 25 percent slopes							177	.10	96	.10
Waihuna gravelly clay, 3 to 7 percent slopes									228	.25
Waikane silty clay, 3 to 8 percent slopes			602	.15						
Waikane silty clay, 8 to 15 percent slopes			247	.06						

TABLE 1.—*Approximate acreage and proportionate extent of the soils*—Continued

HIGH-INTENSITY AND MEDIUM-INTENSITY—Continued

Soil	Kauai		Oahu		Maui		Molokai		Lanai	
	Acres	*Percent*	*Acres*	*Percent*	*Acres*	*Percent*	*Acres*	*Percent*	*Acres*	*Percent*
Waikane silty clay, 25 to 40 percent slopes			3, 976	1. 02						
Waikane silty clay, 40 to 70 percent slopes			5, 743	1. 48						
Waikane silty clay, 40 to 70 percent slopes, eroded			819	. 21						
Waikane stony silty clay, 15 to 30 percent slopes			310	. 08						
Waikapu silty clay loam, 0 to 3 percent slopes							570	. 34	574	. 63
Waikapu silty clay loam, 3 to 7 percent slopes							1, 406	. 84		
Waikapu silty clay loam, 3 to 7 percent slopes, severely eroded							509	. 30		
Waikapu silty clay loam, 7 to 15 percent slopes, severely eroded							1, 019	. 61	143	. 15
Waikomo stony silty clay	1, 539	. 43								
Waikomo very rocky silty clay	1, 910	. 53								
Waikomo extremely rocky silty clay	283	. 07								
Wailuku silty clay, 3 to 7 percent slopes					514	. 11				
Wailuku silty clay, 7 to 15 percent slopes					1, 613	. 34				
Wailuku cobbly silty clay, 7 to 15 percent slopes					578	. 12				
Wainee very stony silty clay, 3 to 7 percent slopes					388	. 08				
Wainee very stony silty clay, 7 to 15 percent slopes					936	. 20				
Wainee extremely stony silty clay, 3 to 7 percent slopes					370	. 07				
Wainee extremely stony silty clay, 7 to 15 percent slopes					1, 093	. 23				
Waipahu silty clay, 0 to 2 percent slopes			1, 328	. 34						
Waipahu silty clay, 2 to 6 percent slopes			345	. 08						
Waipahu silty clay, 6 to 12 percent slopes			656	. 16						
Total	129, 362	35. 97	162, 837	41. 51	105, 090	21. 50	48, 855	29. 15	28, 187	31. 18
LOW-INTENSITY SURVEY										
Alaeloa silty clay, 15 to 35 percent slopes, severely eroded							201	. 12		
Alaeloa silty clay, 40 to 70 percent slopes			2, 757	. 71						
Alaeloa stony silty clay, 15 to 35 percent slopes, severely eroded							354	. 21		
Alaeloa stony silty clay, overwash, 15 to 35 percent slopes							209	. 12		
Badland	1, 624	. 45								
Badland-Mahana complex	5, 681	1. 60								
Beaches	741	. 20	1, 772	. 45	477	. 10	358	. 21	68	. 07
Blown-out land									2, 732	3. 03
Colluvial land							1, 399	. 84		
Coral outcrop			8, 863	2. 29						
Dune land	638	. 17			1, 168	. 25				
Fill land, mixed			9, 713	2. 51						
Gullied land							2, 181	1. 31		
Halawa silty clay, 3 to 25 percent slopes					786	. 16	1, 383	. 83		
Halawa silty clay, 3 to 25 percent slopes, severely eroded							553	. 33		
Halawa silt loam, 20 to 35 percent slopes			429	. 11						
Halawa silt loam, 35 to 70 percent slopes, eroded			654	. 16						
Hana very stony silty clay loam, 3 to 25 percent slopes					7, 492	1. 60				
Hana extremely stony silty clay loam, 3 to 25 percent slopes					572	. 12				
Hana silty clay loam, moderately deep variant, 3 to 15 percent slopes					1, 360	. 29				

TABLE 1.—*Approximate acreage and proportionate extent of the soils* Continued

LOW-INTENSITY SURVEY—Continued

Soil	Kauai		Oahu		Maui		Molokai		Lanai	
	Acres	*Percent*	*Acres*	*Percent*	*Acres*	*Percent*	*Acres*	*Percent*	*Acres*	*Percent*
Hana extremely stony silty clay loam, moderately deep variant, 3 to 15 percent slopes					520	0.11				
Helemano silty clay, 30 to 90 percent slopes			27,778	7.18						
Hihimanu silty clay loam, 40 to 70 percent slopes	8,431	2.37								
Hulua gravelly silty clay loam, 3 to 25 percent slopes	2,472	.69								
Hulua gravelly silty clay loam, 25 to 70 percent slopes	2,850	.80								
Io silt loam, 7 to 25 percent slopes					3,302	.70				
Jaucas-Blown-out land complex							1,174	.70		
Kahanui silty clay, 3 to 20 percent slopes									351	.39
Kahanui gravelly silty clay, 3 to 20 percent slopes							1,972	1.18		
Kailua silty clay, 3 to 25 percent slopes					6,630	1.42				
Kaimu extremely stony peat, 7 to 25 percent slopes					1,990	.42				
Kaipoioi loam, 7 to 40 percent slopes					5,933	1.27				
Kaipoioi very rocky loam, 7 to 40 percent slopes					4,522	.97				
Kalapa very rocky silty clay, 40 to 70 percent slopes	1,851	.52								
Kalaupapa very rocky silty clay loam, 3 to 25 percent slopes							1,359	.81		
Kamaole very stony silt loam, 3 to 15 percent slopes					7,714	1.65				
Kamaole extremely stony silt loam, 3 to 15 percent slopes					1,018	.21				
Kaneohe silty clay loam, 5 to 15 percent slopes			348	.09						
Kaneohe silty clay loam, 15 to 30 percent slopes			210	.05						
Kaneohe silty clay loam, 30 to 65 percent slopes			400	.10						
Kaneohe silty clay, 30 to 65 percent slopes			401	.10						
Kapaa silty clay, 40 to 100 percent slopes			12,119	3.13						
Kapuhikani extremely stony clay, 3 to 15 percent slopes							1,250	.75		
Kaupo very stony silty clay loam, 3 to 25 percent slopes					1,914	.41				
Kaupo extremely stony silty clay, 3 to 25 percent slopes					564	.12				
Kealia silt loam					1,110	.23	1,430	.85		
Keawakapu extremely stony silty clay loam, 3 to 25 percent slopes					4,679	1.00				
Kekaha extremely stony silty clay loam, 0 to 35 percent slopes	1,102	.31								
Kemoo-Badland complex			961	.24						
Koele-Badland complex							527	.31	6,630	7.36
Koele rocky complex					1,698	.36				
Kokee silty clay loam, 0 to 35 percent slopes	2,435	.68								
Kokee silty clay loam, 35 to 70 percent slopes	3,669	1.03								
Kokokahi very stony clay, 0 to 35 percent slopes			300	.07						
Kolokolo extremely stony clay loam	1,982	.55								
Koolau silty clay, 0 to 8 percent slopes	1,056	.29								
Koolau silty clay, 8 to 30 percent slopes	652	.18								
Kunuweia very gravelly clay loam, 0 to 15 percent slopes	801	.22								
Laumaia loam, 7 to 40 percent slopes					5,800	1.24				
Laumaia loam, 40 to 70 percent slopes					720	.15				
Laumaia extremely stony loam, 7 to 40 percent slopes					4,496	.96				
Lualualei extremely stony clay, 3 to 35 percent slopes	361	.10	5,936	1.53						
Mahana-Badland complex			2,533	.65						

TABLE 1.—*Approximate acreage and proportionate extent of the soils*—Continued

LOW-INTENSITY SURVEY—Continued

Soil	Kauai		Oahu		Maui		Molokai		Lanai	
	Acres	*Percent*	*Acres*	*Percent*	*Acres*	*Percent*	*Acres*	*Percent*	*Acres*	*Percent*
Makaalae silty clay, 7 to 25 percent slopes					4,374	0.93				
Makaalae extremely stony silty clay, 7 to 25 percent slopes					2,054	.44				
Makaalae clay, 7 to 40 percent slopes					570	.12				
Makena loam, stony complex, 3 to 15 percent slopes					2,962	.63				
Malama extremely stony muck, 3 to 25 percent slopes					2,960	.63				
Marsh	652	.18	960	.24			599	.36		
Naiwa silty clay loam, 3 to 20 percent slopes					929	.19	925	.55	52	.05
Naiwa silty clay loam, 7 to 15 percent slopes, severely eroded							623	.37		
Niulii silty clay loam, 7 to 30 percent slopes							288	.17		
Niulii silty clay loam, medium textured variant, 7 to 30 percent slopes							535	.32		
Oanapuka very stony silt loam, 7 to 25 percent slopes					658	.14				
Oanapuka extremely stony silt loam, 7 to 25 percent slopes					5,720	1.22				
Olelo silty clay, 3 to 15 percent slopes					2,251	.48	1,449	.87		
Oli silt loam, 3 to 10 percent slopes					372	.07				
Oli silt loam, 10 to 30 percent slopes	1,122	.32					2,554	1.53		
Oli silt loam, 30 to 70 percent slopes	3,037	.86					1,008	.60		
Olinda loam, 4 to 12 percent slopes					213	.04				
Olinda loam, 12 to 20 percent slopes					2,816	.60				
Olinda loam, 20 to 40 percent slopes					1,596	.34				
Olokui silty clay loam, 3 to 30 percent slopes							841	.50	22	.02
Opihikao extremely rocky muck, 3 to 25 percent slopes					412	.08				
Paaiki loam, 6 to 35 percent slopes	1,828	.51								
Paaiki loam, 35 to 70 percent slopes	733	.20								
Pakala extremely stony sandy clay loam, 0 to 12 percent slopes	914	.25								
Pamoa silty clay, 5 to 20 percent slopes			409	.11			774	.46	283	.31
Pamoa silty clay, 5 to 20 percent slopes, eroded							1,054	.63	271	.30
Pamoa stony silty clay, 5 to 20 percent slopes, eroded							1,087	.65		
Pane silt loam, 7 to 25 percent slopes					3,246	.69				
Papaa clay, 6 to 20 percent slopes			259	.06						
Papaa clay, 20 to 35 percent slopes			233	.06						
Papaa clay, 35 to 70 percent slopes			631	.16						
Paumalu-Badland complex			5,340	1.38						
Puuone sand, 7 to 30 percent slopes					4,579	.98				
Puu Pa very stony silt loam, 7 to 40 percent slopes					15,282	3.27				
Tantalus silt loam, 15 to 40 percent slopes			264	.06						
Tantalus silt loam, 40 to 70 percent slopes			919	.23						
Tantalus silty clay loam, 8 to 15 percent slopes			576	.14						
Tantalus silty clay loam, 15 to 40 percent slopes			339	.08						
Tropaquepts			488	.12	180	.03				
Ulupalakua silt loam, 7 to 25 percent slopes					1,986	.42				
Uma loamy coarse sand, 15 to 40 percent slopes					1,724	.37				
Uma loamy coarse sand, 40 to 70 percent slopes					2,631	.56				
Uma rocky loamy coarse sand, 7 to 25 percent slopes					936	.20				
Waiakoa extremely stony silty clay loam, 3 to 25 percent slopes, eroded					13,424	2.88				

TABLE 1.—*Approximate acreage and proportionate extent of the soils*—Continued

LOW-INTENSITY SURVEY—Continued

Soil	Kauai		Ohau		Maui		Molokai		Lanai	
	Acres	*Percent*	*Acres*	*Percent*	*Acres*	*Percent*	*Acres*	*Percent*	*Acres*	*Percent*
Waiawa extremely rocky clay, 30 to 80 percent slopes	8, 903	2. 50								
Total	53, 535	14. 98	85, 592	22. 01	136, 340	29. 05	26, 087	15. 58	10, 409	11. 53

RECONNAISSANCE SURVEY

Soil	Kauai		Ohau		Maui		Molokai		Lanai	
	Acres	*Percent*	*Acres*	*Percent*	*Acres*	*Percent*	*Acres*	*Percent*	*Acres*	*Percent*
Alakai mucky peat, 0 to 30 percent slopes	6, 646	1. 87	319	. 08						
Amalu peaty silty clay, 3 to 20 percent slopes					5, 684	1. 21	1, 034	. 62		
Amalu-Olokui association, 3 to 20 percent slopes							1, 004	. 60		
Cinder land			579	. 14	9, 978	2. 14				
Honomanu silty clay, 5 to 25 percent slopes					1, 936	. 41				
Honomanu-Amalu association					10, 186	2. 18				
Hydrandepts-Tropaquods association					41, 525	8. 91				
Lava flows, Aa					9, 030	1. 93				
Riverwash	902	. 25								
Rock land	1, 382	. 38	37, 537	9. 71	13, 762	2. 95	8, 800	5. 28	7, 007	7. 78
Rock outcrop	41, 786	11. 77	7, 749	2. 00	16, 244	3. 48	7, 241	4. 35	5, 890	6. 54
Rough broken land	46, 368	13. 06			14, 731	3. 16	8, 964	5. 38	1, 045	1. 16
Rough broken and stony land					3, 035	. 65				
Rough mountainous land	69, 502	19. 57	59, 790	15. 46	52, 122	11. 18	32, 960	19. 80	2, 867	3. 18
Rubble land	925	. 26								
Sandy alluvial land									475	. 52
Stony alluvial land					4, 683	1. 00	811	. 48	216	. 24
Stony blown-out land									1, 415	1. 57
Stony colluvial land							753	. 45		
Stony land			6, 530	1. 68						
Stony steep land			8, 064	2. 08						
Tropaquods							4, 611	2. 77		
Tropohumults-Dystrandepts association			17, 463	4. 51						
Very stony land					41, 574	8. 92	8, 921	5. 36	15, 180	16. 86
Very stony land, eroded							16, 228	9. 75	17, 314	19. 23
Waialeale mucky silty clay loam, 30 to 70 percent slopes	4, 581	1. 29								
Total	172, 092	48. 45	138, 031	35. 66	224, 490	48. 12	91, 327	54. 84	51, 409	57. 08

ity is about 1.2 inches per foot in the surface layer and 0.9 inch per foot in the substratum. In some places roots penetrate to a depth of 4 feet or more.

Representative profile: Island of Maui, lat. 20°50′20″ N. and long. 156°25′53″ W.

A11—0 to 2 inches, very dark brown (10YR 2/2) cobbly sandy loam, very dark grayish brown (10YR 3/2) when dry; weak, fine, granular structure; soft, very friable, nonsticky and nonplastic; plentiful very fine roots; many fine pores; many ash particles, up to 2 millimeters in diameter, that do not break down with continued rubbing; neutral; clear, smooth boundary. 2 to 3 inches thick.

A12—2 to 7 inches, very dark grayish-brown (10YR 3/2) sandy loam, brown (10YR 4/4) when dry; massive; soft, very friable, nonsticky and nonplastic; plentiful fine roots; many fine and very fine pores; many ash particles, up to 2 millimeters in diameter, that do not break down with continued rubbing; a few thin layers of yellowish-red (5YR 4/6), slightly decomposed, volcanic cinders (0.15 to 1 millimeter); mildly alkaline; clear, wavy boundary. 4 to 8 inches thick.

C1—7 to 14 inches, very dark grayish-brown (10YR 3/2) sandy loam, brown (10YR 4/3) when dry; massive; soft, very friable, nonsticky and nonplastic; few very fine roots; common very fine pores; many ash particles, up to 2 millimeters in diameter, that do not break down with continued rubbing; slight effervescence with hydrochloric acid; mildly alkaline; abrupt, wavy boundary. 5 to 15 inches thick.

IIC2ca—14 to 29 inches, very dark gray (10YR 3/1) coarse and very coarse sand, gray (10YR 5/1) when dry; single grain; loose; many ash particles up to 2 millimeters in diameter; many pebble-size fragments of basalt; violent effervescence with hydrochloric acid; moderately alkaline; clear, wavy boundary. 10 to 18 inches thick.

IIIC3ca—29 to 55 inches, grayish-brown (10YR 5/2) very coarse sand, gray (10YR 5/1) when dry; single grain; loose; 40 to 50 percent gravel and cobblestones; many volcanic ash particles up to 2 millimeters in diameter; strong effervescence with hydrochloric acid; moderately alkaline.

The content of cobblestones in the A horizon ranges from 5 to 40 percent. In places there are no cobblestones in this horizon. The A horizon ranges from 10YR to 7.5YR in hue, from 2 to 3 in value when moist and from 3 to 5 when dry, and from 1 to 3 in chroma when moist or dry. The C horizon is stratified and has textures of sandy loam, coarse sand, and very coarse sand. In some places a few bands of volcanic ash, ¼ to ¾ inch thick, occur in the C horizon.

This soil is used for sugarcane and pasture. (Capability classification IVs if irrigated, VIs if nonirrigated; sugarcane group 1; pasture group 1)

Alae cobbly sandy loam, 3 to 7 percent slopes (AcB).—On this soil, runoff is slow and the erosion hazard is slight.

This soil is used for sugarcane and pasture. (Capability classification IVs if irrigated, VIs if nonirrigated; sugarcane group 1; pasture group 1)

Alae sandy loam, 3 to 7 percent slopes (AaB).—This soil is similar to Alae cobbly sandy loam, 0 to 3 percent slopes, except that there are no cobblestones on the surface. Runoff is slow, and the erosion hazard is slight. Included in mapping were small, nearly level areas. In places there are few to many pebble-size rock fragments in the surface layer.

Most of this soil is used for sugarcane and pasture. A small acreage is used for truck crops. (Capability classification IVs if irrigated, VIs if nonirrigated; sugarcane group 1; pasture group 1)

Alaeloa Series

This series consists of well-drained soils on uplands on the islands of Maui, Molokai, and Oahu. These soils developed in material weathered from basic igneous rock. They are gently sloping to very steep. Elevations range from 100 to 1,500 feet. The annual rainfall amounts to 35 to 60 inches, and it is well distributed throughout the year. The mean annual soil temperature is 72° F. Alaeloa soils are geographically associated with Kaneohe, Lolekaa, Papaa, Waikane, Honolua, and Kahana soils.

These soils are used for pineapple, pasture, wildlife habitat, homesites, and water supply. Small acreages are used for truck crops and orchards. The natural vegetation consists of guava, Java plum, Christmas berry, Japanese tea, and hilograss.

Alaeloa silty clay, 15 to 35 percent slopes (AeE).—This soil occurs on smooth side slopes and toe slopes in the uplands. Included in mapping were small areas of dark-brown soils on uplands and wet soils in the drainageways. Also included were small, eroded areas and gently sloping to moderately sloping areas.

In a representative profile the surface layer is dark reddish-brown silty clay about 10 inches thick. The subsoil, about 48 inches thick, is dark-red and red silty clay that has subangular blocky structure. The substratum is soft, weathered basic igneous rock. The soil is medium acid in the surface layer and strongly acid in the subsoil.

Permeability is moderately rapid. Runoff is medium, and the erosion hazard is moderate. The available water capacity is about 1.2 inches per foot in the surface layer and 1.6 inches per foot in the subsoil. Roots penetrate to a depth of 5 feet or more in places. Workability is difficult because of the slope.

Representative profile: Island of Oahu, lat. 21°21′50″ N. and long. 157°44′27″ W.

Ap—0 to 10 inches, dark reddish-brown (5YR 3/3) silty clay, reddish brown (5YR 4/3) when dry; strong, very fine and fine, subangular blocky structure; hard, firm, sticky and plastic; abundant fine and medium roots; many very fine roots; many, very fine and fine, interstitial and tubular pores; common wormholes and worm casts; some dark-red material from B horizon mixed by cultivation; slight effervescence with hydrogen peroxide; medium acid; abrupt, wavy boundary. 9 to 10 inches thick.

B21t—10 to 18 inches, dark-red (2.5YR 3/6) silty clay, red (2.5YR 4/6) when dry; strong, very fine, subangular blocky structure; hard, friable, sticky and plastic; abundant fine roots; common, very fine and fine, tubular pores; few, medium, tubular pores; few wormholes and worm casts; thin, continuous clay films on peds; strongly acid; clear, wavy boundary. 6 to 8 inches thick.

B22t—18 to 29 inches, dark-red (2.5YR 3/6) silty clay, red (2.5YR 4/6) when dry; strong, very fine and medium, subangular blocky structure; hard, friable, sticky and plastic; abundant very fine roots; few, fine, tubular pores; thin, continuous clay films on peds; some films are dark red and some dark brown; strongly acid; gradual, wavy boundary. 9 to 13 inches thick.

B23t—29 to 48 inches, coarse pattern of red (10R 5/6, 2.5YR 4/6 and 4/8) silty clay; red (10R 4/6), dark red (2.5YR 3/6), and dark reddish brown (2.5YR 3/4) when moist; strong, very fine and fine, subangular blocky structure; hard, friable, sticky and plastic; few fine roots; many, very fine, tubular pores and common, fine, tubular pores; thick, continuous, dark-red clay films in vertical cracks; coated ped faces; some granular (sugarlike) material on peds; few soft rock fragments; strongly acid; clear, wavy boundary. 18 to 26 inches thick.

B24t—48 to 58 inches, red (2.5YR 4/6) silty clay, red (2.5YR 5/6) when dry; strong, very fine and medium, subangular blocky structure; hard, friable, sticky and plastic; few fine roots; many, very fine and fine, tubular pores; thick, continuous clay films on peds; weak slickensides; many black specks; many soft, highly weathered rock fragments; strongly acid.

The A horizon ranges from 5YR to 2.5YR in hue, and, when moist, from 2 to 3 in value and chroma. The B horizon ranges from 2.5YR to 10R in hue. It ranges from 2 to 5 in value when moist or dry and from 4 to 6 in chroma when moist and 6 to 8 when dry. The Bt horizon ranges from silty clay to clay loam in texture. Slickensides and organic stains in the Bt horizon range from few to many. In most places depth to the soft, highly weathered parent rock ranges from 3 feet to more than 5 feet. In some places there are stones on the surface or in the profile or areas of rock outcrop.

This soil is used for pineapple, pasture, truck crops, orchards, wildlife habitat, and homesites. Small areas are used for sugarcane. (Capability classification VIe, nonirrigated; pineapple group 6; pasture group 6; woodland group 5)

Alaeloa silty clay, 3 to 7 percent slopes (AeB).—On this soil, runoff is slow and the erosion hazard is slight. Workability is easy. Included in mapping were small, nearly level areas.

This soil is used for pineapple. A small acreage is used for pasture and homesites. (Capability classification IIe, irrigated or nonirrigated; pineapple group 5; pasture group 6; woodland group 5)

Alaeloa silty clay, 7 to 15 percent slopes (AeC).—On this soil, runoff is slow to medium and the erosion hazard is slight to moderate. Workability is slightly difficult.

This soil is used for pineapple. A small acreage is used for pasture and homesites. (Capability classification IIIe, irrigated or nonirrigated; pineapple group 6; pasture group 6; woodland group 5)

Alaeloa silty clay, 40 to 70 percent slopes (ALF).—In areas of this soil, the most common slope range is 45 to 53 percent. Runoff is rapid to very rapid, and the erosion hazard is severe. Included in mapping were small areas

on slopes of less than 35 percent, stony areas, and rock outcrops.

This soil is used for pasture and wildlife habitat. (Capability classification VIIe, nonirrigated; pasture group 6; woodland group 15)

Alaeloa silty clay, 15 to 35 percent slopes, severely eroded (ALE3).—This soil has a profile like that of Alaeloa silty clay, 15 to 35 percent slopes, except that much of the surface layer and, in places, some of the subsoil has been removed by erosion. Many small included areas have been eroded to soft, highly weathered rock. Most areas are nearly free of stones, but some small areas that are eroded to weathered rock are very stony. Runoff is rapid, and the erosion hazard is severe.

This soil is used for pasture and wildlife habitat. (Capability classification VIIe, nonirrigated; pasture group 6; woodland group 5)

Alaeloa stony silty clay, 15 to 35 percent slopes, severely eroded (AME3).—This soil has a profile like that of Alaeloa silty clay, 15 to 35 percent slopes, except that most of the surface layer and, in places, some of the subsoil has been removed by erosion. Highly weathered rock is exposed in many places. There are many stones and some rock outcrop on the surface. In a few places there are boulders as much as 4 feet in diameter. Runoff is rapid, and the erosion hazard is severe.

This soil is used for pasture and wildlife habitat. (Capability classification VIIe, nonirrigated; pasture group 6; woodland group 5)

Alaeloa stony silty clay, overwash, 15 to 35 percent slopes (ANE).—This soil has a profile like that of Alaeloa silty clay, 15 to 35 percent slopes, except that it has an overburden of dark-brown stony silty clay, 1 foot to 4 feet thick. Stones and gravel occur throughout the profile. The soil is on toe slopes and in depressions where fine-textured alluvium has accumulated. The erosion hazard is severe, and gullies are common. About 10 percent of this soil is nonstony.

This soil is used for pasture and wildlife habitat. (Capability classification VIe, nonirrigated; pasture group 6; woodland group 5)

Alakai Series

This series consists of very poorly drained soils on uplands on the islands of Kauai and Oahu. These soils formed by the deposition and decomposition of organic matter over basalt, under wet conditions. They are level to moderately steep. Elevations range from 3,000 to 5,000 feet. The annual rainfall amounts to 100 to 450 inches. There is cloud and fog cover almost daily. The mean annual soil temperature is 56° F. Alakai soils are geographically associated with Waialeale soils.

These soils are not cultivated, because they are always wet. They are used for water supply and wildlife habitat. The natural vegetation consists of ohia lehua, Hawaiian lobelia, mokihana, puakeawe, treefern, and other rainforest vegetation.

Alakai mucky peat, 0 to 30 percent slopes (rAAE).—This soil occurs on mountaintops and high ridges. Included in mapping were small areas of hypnum moss peat. In these areas the water table is at or near the surface, and the vegetation consists of mosses, scrub ohia, and puakeawe. Also included was a small area of Alakai soil mapped at an elevation below 2,000 feet.

In a representative profile the surface layer is very dusky red mucky peat about 8 inches thick. Below this is dark reddish-brown, reddish-black, and very dusky red muck about 24 inches thick. The texture of the substratum is clay. Some layers are gray, and some are greenish gray.

Permeability is slow below the muck. Runoff is slow, and the erosion hazard is slight. Reaction is extremely acid.

Representative profile: Island of Kauai, lat. 22°09′25″ N. and long. 159°35′48″ W.

1—0 to 8 inches, very dusky red (10R 2/2) mucky peat, reddish black (10R 2/1) when dry; massive; extremely hard, friable, smeary and nonsticky and nonplastic; abundant roots; extremely acid; clear, smooth boundary. 7 to 12 inches thick.

2—8 to 14 inches, reddish-black (10R 2/1) muck, reddish black (10R 2/1) when dry; massive; extremely hard, firm, smeary and slightly sticky and slightly plastic; abundant roots; extremely acid; clear, smooth boundary. 5 to 9 inches thick.

3—14 to 22 inches, dark reddish-brown (2.5YR 2/4) muck, reddish black (10R 2/1) when dry; massive; extremely hard, friable, smeary and slightly sticky and slightly plastic; abundant roots; extremely acid; clear, smooth boundary. 6 to 10 inches thick.

4—22 to 32 inches, very dusky red (2.5YR 2/2) muck, black (N 2/0) when dry; massive; extremely hard, friable, smeary and slightly sticky and slightly plastic; abundant roots; extremely acid; abrupt, smooth boundary. 6 to 10 inches thick.

IIC1—32 to 38 inches, gray (N 6/0 and 5Y 5/1), brown (7.5YR 5/4), and reddish-yellow (7.5YR 6/8) clay; rubbed (mixed) color is grayish brown (2.5Y 5/2), gray (2.5Y 6/1) when dry; massive; very hard, firm, very sticky and very plastic; few very fine and micro roots; common micro pores; this layer is capped by 1 to 2 inches of gravelly clay; extremely acid; clear, smooth boundary. 4 to 8 inches thick.

IIC2—38 to 51 inches, gray (N 6/0) and grayish-brown (2.5Y 5/2) clay, gray (N 6/0 and 5Y 6/1) and light gray (5Y 7/1) when dry; massive; very hard, firm, very sticky and very plastic; few very fine roots; common micro pores; some irregularly shaped pebbles, ½ inch to 2 inches across; extremely acid.

The depth to clay ranges from 18 to 36 inches. In places the clay rests on an ironstone sheet ⅛ inch to 4 inches thick. The organic layers range from 10R to 5YR in hue. The values are 2 to 3 when moist and 2 when dry. The clay layers are brown, gray, and greenish gray. They range from 5 to 7 in value and from 0 to 1 in chroma when moist or dry.

This soil is used for water supply and wildlife habitat. (Capability classification VIIw, nonirrigated; woodland group 16)

Amalu Series

This series consists of poorly drained soils on dissected uplands on the islands of Maui and Molokai. These soils developed in organic material and material weathered from basic igneous rock. They are gently sloping to moderately steep. Elevations range from 2,000 to 5,500 feet. The annual rainfall amounts to 75 to 400 inches. Fog and cloud cover are present most days throughout the year. The mean annual soil temperature is 58° F. Amalu soils are geographically associated with Honomanu, Kahanui, and Olokui soils.

These soils are used for water supply and wildlife habitat. The natural vegetation consists of clubmoss, lapalapa, ohelo, ohia, sedges, false staghornfern, and treefern.

Amalu peaty silty clay, 3 to 20 percent slopes (rAMD).—This soil is on high ridges and mountaintops. Included in mapping were small areas of Honomanu and Olokui soils and of steep gulches.

In a representative profile an organic layer of black peat, about 8 inches thick, overlies a layer of gray massive clay about 8 inches thick. The substratum is soft, weathered basic igneous rock capped by a horizontal ironstone sheet 1/8 to 1 inch thick. The soil is extremely acid above the ironstone layer.

Permeability is restricted by the ironstone sheet, which is impermeable except for cracks. Runoff is very slow, and the erosion hazard is no more than slight. Roots penetrate to a depth of 8 to 15 inches in places.

Representative profile: Island of Maui, lat. 20°48′46″ N. and long. 156°13′44″ W.

O1—8 inches to 0, black (5YR 2/1) peat; massive; soft, nonsticky and nonplastic; abundant medium and coarse roots; extremely acid; abrupt, wavy boundary. 5 to 15 inches thick.

A2g—0 to 8 inches, gray (10YR 5/1) clay; massive; firm, sticky, plastic and weakly smeary; abundant roots; many, fine and medium, tubular pores; common dark-gray (10YR 4/1) organic stains; extremely acid; abrupt, smooth boundary. 4 to 15 inches thick.

B2irm—8 to 8¼ inches, dark reddish-brown (5YR 2/2) horizontal, laminar ironstone sheet that has a surface that appears to be troweled; thin coating of yellowish-red (5YR 4/6) soft material on upper surface. 1/8 to 1 inch thick.

C—8¼ to 60 inches +, very dark gray (10YR 3/1) saprolite that has light-gray (10YR 7/1) and yellowish-red (5YR 5/6) colors in and adjacent to cracks; breaks down to smeary silt loam; saprolite has some original rock structure; soft plinthite in cracks or coatings around rock cores; few, hard, discontinuous ironstone sheets, up to 1 inch thick, oriented horizontally and vertically. Many feet thick.

The depth to the ironstone sheet ranges from 8 to 15 inches below the base of the O1 horizon. The A2g horizon ranges from 10YR to 5Y in hue, from 2 to 5 in value, and from 1 to 2 in chroma. In places a black mucky layer, 1 to 2 inches thick, occurs between the A2g and B2irm horizons.

This soil is used for water supply and wildlife habitat. (Capability classification VIIw, nonirrigated; woodland group 16)

Amalu-Olokui association, 3 to 20 percent slopes (rAOD).—This association consists of Amalu peaty silty clay, 3 to 20 percent slopes, and Olokui silty clay loam, 3 to 30 percent slopes. It is on intermediate uplands in the eastern part of the island of Molokai. Amalu soils make up about 60 percent of the association, and Olokui soils about 40 percent. Amalu soils occupy the depressions and the wetter sites. Included in mapping were small areas of Kahanui soils and many small, very steep gulches.

This association is used for water supply and wildlife habitat. (Amalu part is in capability classification VIIw, nonirrigated; woodland group 16. Olokui part is in capability classification VIIIw, nonirrigated; woodland group 16)

Badland

Badland consists of steep or very steep, nearly barren land, ordinarily not stony. The soil-forming material is generally soft or hard saprolite. The annual rainfall amounts to 22 to 60 inches. Elevations range from nearly sea level to about 3,000 feet. This land type is mapped on the island of Kauai and, in addition, as part of soil complexes on Lanai, Molokai, and Oahu.

Badland (BL).—This land type occurs on the island of Kauai. It is steep to very steep and nearly barren. Runoff is very rapid, and geological erosion is active. Included in mapping were areas of Kalapa, Lihue, and Makaweli soils.

This land type is used for water supply and wildlife habitat. Ironwood trees have been planted in small areas. (Capability classification VIIIe, nonirrigated)

Badland-Mahana complex (BM).—This complex occurs on the western side of the island of Kauai. Badland makes up about 60 percent of the acreage; Mahana silt loam, 20 to 35 percent slopes, makes up about 40 percent. Elevations range from 1,500 to 3,000 feet. The annual rainfall amounts to 30 to 45 inches. Slopes are steep to very steep.

Most of the Badland part of this complex is barren, but some areas have been planted to ironwood, silk-oak, and eucalyptus. The Mahana part is used for pasture and woodland. (Badland part is in capability classification VIIIe, nonirrigated. Mahana part is in capability classification VIe, nonirrigated; pasture group 6; woodland group 5)

Beaches

Beaches (BS) occur as sandy, gravelly, or cobbly areas on all the islands in the survey area. They are washed and rewashed by ocean waves. The beaches consist mainly of light-colored sands derived from coral and seashells. A few of the beaches, however, are dark colored because their sands are from basalt and andesite.

Beaches have no value for farming. Where accessible and free of cobblestones and stones, they are highly suitable for recreational uses and resort development. (Capability classification VIIIw, nonirrigated)

Blown-out Land

Blown-out land (BW) occurs mainly on the windswept northern plateau of the island of Lanai. The slope ranges from 0 to 15 percent, but included in mapping were areas adjacent to gulches and hummocks, where the slope is as much as 40 percent. Elevations range from 1,500 to 1,700 feet. The annual rainfall amounts to 15 to 25 inches. Strong trade winds are common. Most areas are barren and are eroded to the compact subsoil or to soft, weathered rock. The subsoil material is similar to that of Kanepuu and Lahaina soils. As much as 10 percent of the area has hummocks or small dunes that are partly stabilized by dallisgrass, molassesgrass, bermudagrass, and ilima. Runoff is rapid, and the erosion hazard is severe.

The main management requirement on this land type is the provision of vegetative cover to check further loss of soil material. Test plantings of pineapple have indi-

cated that Blown-out land is very deficient in zinc, as well as in major nutrient elements. (Capability classification VIIe, nonirrigated)

Cinder Land

Cinder land (rCI) consists of areas of bedded magmatic ejecta associated with cinder cones. It is a mixture of cinders, pumice, and ash. These materials are black, red, yellow, brown, or variegated in color. They have jagged edges and a glassy appearance and show little or no evidence of soil development.

Cinder land occurs on the islands of Maui and Oahu. On Maui, it is mainly at elevations between 8,000 and 10,000 feet, in the Haleakala National Park. On Oahu, it is mainly at elevations between 200 and 2,000 feet, near Mount Tantalus. The annual rainfall amounts to 20 to 30 inches on Maui and 60 to 100 inches on Oahu.

Although Cinder land commonly supports some vegetation, it has no value for grazing, because of its loose nature and poor trafficability. It is used for wildlife habitat and recreational areas. (Capability classification VIIIs, nonirrigated)

Colluvial Land

Colluvial land (CO) consists of steep and very steep talus slopes in windward valleys on the island of Molokai. It occurs in isolated valleys that are accessible only by long mountain trails or by boat during the summer months. It is characterized by a mixture of soil material, gravel, stones, and boulders moved by gravity and water. The soil material is very dark brown silty clay loam and silty clay. The slope generally ranges from 25 to 60 percent, but it is more gentle along valley bottoms. There are many intermittent streams throughout this area. Elevations range from sea level to 1,000 feet. The annual rainfall amounts to 70 to 100 inches.

This land type is used for watershed and for wildlife habitat. The vegetation consists of dense stands of guava, kukui, ginger, honohono, hilograss, and associated plants. (Capability classification VIIe, nonirrigated; woodland group 15)

Coral Outcrop

Coral outcrop (CR) consists of coral or cemented calcareous sand on the island of Oahu. The coral reefs formed in shallow ocean water during the time the ocean stand was at a higher level. Small areas of coral outcrop are exposed on the ocean shore, on the coastal plains, and at the foot of the uplands. Elevations range from sea level to approximately 100 feet. The annual rainfall amounts to 18 to 40 inches. Coral outcrop is geographically associated with Jaucas, Keaau, and Mokuleia soils.

Coral outcrop makes up about 80 to 90 percent of the acreage. The remaining 10 to 20 percent consists of a thin layer of friable, red soil material in cracks, crevices, and depressions within the coral outcrop. This soil material is similar to that of the Mamala series.

This land type is used for military installations, quarries, and urban development. Vegetation is sparse. It consists of kiawe, koa haole, and fingergrass. (Capability classification VIIIs, nonirrigated)

Dune Land

Dune land (DL) consists of hills and ridges of sand-size particles drifted and piled by wind. The hills and ridges are actively shifting or are so recently fixed or stabilized that no soil horizons have developed. The sand is dominantly from coral and seashells. This miscellaneous land type occurs in coastal areas on the islands of Maui and Kauai. Elevations range from nearly sea level to 150 feet. The annual rainfall amounts to 15 to 90 inches.

This land type is used for wildlife habitat and recreational areas and as a source of liming material. Vegetation is sparse, but ironwood trees, koa haole, tropical almond, kiawe, and mixed grasses have gained a foothold in places. (Capability classification VIIIe, nonirrigated)

Ewa Series

This series consists of well-drained soils in basins and on alluvial fans on the islands of Maui and Oahu. These soils developed in alluvium derived from basic igneous rock. They are nearly level to moderately sloping. Elevations range from near sea level to 150 feet. The annual rainfall amounts to 10 to 30 inches. Most of it occurs between November and April. The mean annual soil temperature is 73° F. Ewa soils are geographically associated with Honouliuli, Mamala, Molokai, Pulehu, and Waiakoa soils.

These soils are used for sugarcane, truck crops, and pasture. The natural vegetation consists of fingergrass, kiawe, koa haole, klu, and uhaloa.

Ewa silty clay loam, 3 to 6 percent slopes (EaB).—This soil occurs on alluvial fans and terraces. Included in mapping were small areas of Honouliuli and Mamala soils. Also included were small areas of soils that have a silt loam surface layer and subsoil.

In a representative profile the surface layer is dark reddish-brown silty clay loam about 18 inches thick. The subsoil, about 42 inches thick, is dark reddish-brown and dark-red silty clay loam that has subangular blocky structure. The substratum is coral limestone, sand, or gravelly alluvium. The soil is neutral in the surface layer and subsoil.

Permeability is moderate. Runoff is slow, and the erosion hazard is slight. The available water capacity is about 1.3 inches per foot in the surface layer and 1.4 inches per foot in the subsoil. This soil is more than 60 inches deep. In places roots penetrate to a depth of 5 feet or more.

Representative profile: Island of Oahu, lat. 21°22′20″ N. and long. 158°03′33″ W.

Ap1—0 to 13 inches, dark reddish-brown (5YR 2/3) silty clay loam, dark reddish brown (5YR 3/3) when dry; cloddy, breaking to weak, fine, and very fine, granular structure; hard, friable, sticky and plastic; abundant fine and very fine roots; many, fine and very fine, interstitial pores; common wormholes and worm casts; many, very fine, black concretions that effervesce strongly with hydrogen peroxide; neutral; clear, wavy boundary. 11 to 13 inches thick.

Ap2—13 to 18 inches, dark reddish-brown (2.5YR 3/3) silty clay loam, dark reddish brown (2.5YR 3/4) when dry; weak, fine and very fine, granular structure; hard, friable, sticky and plastic; abundant fine and very fine roots; common, very fine, tubular and interstitial pores; many, very fine, black concretions that

effervesce strongly with hydrogen peroxide; clear, wavy boundary. 3 to 6 inches thick.

B21—18 to 45 inches, dark reddish-brown (2.5YR 3/4) silty clay loam, dark red (2.5YR 3/6) when dry; weak, fine and very fine, subangular blocky structure; hard, friable, sticky and plastic; plentiful very fine and fine roots; many, fine and very fine, tubular pores; common, medium, tubular pores, and few, coarse, tubular pores; weak, patchy pressure cutans on ped faces; few reddish-yellow and yellow sand grains; common, very fine, black concretions that effervesce strongly with hydrogen peroxide; neutral; diffuse, wavy boundary. 25 to 28 inches thick.

B22—45 to 60 inches, dark-red (2.5YR 2/5) silty clay loam, dark red (2.5YR 3/6) when dry; moderate, medium and fine, subangular blocky structure; hard, friable, slightly sticky and plastic; plentiful fine and very fine roots; many, fine and very fine, tubular pores and few, medium, tubular pores; many, thin, patchy coatings that are nearly continuous with depth; many sand grains; many, very fine, black concretions that effervesce strongly with hydrogen peroxide; neutral.

The depth to coral limestone or gravelly alluvium ranges from 50 to more than 60 inches. In some areas cobblestones and stones occur on the surface and in the surface layer. The A and B horizons range from 5YR to 2.5YR in hue and, when moist, from 2 to 3 in value and from 3 to 5 in chroma. The texture of the A horizon is silty clay loam or silty clay. The structure in the B horizon ranges from weak to moderate.

This soil is used for sugarcane, truck crops, and pasture. (Capability classification IIe if irrigated, IVc if nonirrigated; sugarcane group 1; pineapple group 2; pasture group 2)

Ewa silty clay loam, 0 to 3 percent slopes (EaA).—On this soil, runoff is very slow and the erosion hazard is no more than slight. In a few places small, gently sloping areas were included in mapping.

This soil is used for sugarcane and homesites. (Capability classification I if irrigated, IVc if nonirrigated; sugarcane group 1; pineapple group 1; pasture group 2)

Ewa silty clay loam, 6 to 12 percent slopes (EaC).—On this soil, runoff is slow to medium and the erosion hazard is slight to moderate. Included in mapping were a few small areas that are strongly sloping.

This soil is used for sugarcane and pasture. (Capability classification IIIe if irrigated, IVe if nonirrigated; sugarcane group 1; pineapple group 3; pasture group 2)

Ewa silty clay loam, moderately shallow, 0 to 2 percent slopes (EmA).—This soil has a profile like that of Ewa silty clay loam, 3 to 6 percent slopes, except that the depth to coral limestone is 20 to 50 inches. Runoff is very slow, and the erosion hazard is no more than slight. Included in mapping were a few small areas less than 20 inches deep.

This soil is used for sugarcane, truck crops, and pasture. (Capability classification IIs if irrigated, IVs if nonirrigated; sugarcane group 1; pineapple group 1; pasture group 2)

Ewa silty clay loam, moderately shallow, 2 to 6 percent slopes (EmB).—This soil has a profile like that of Ewa silty clay loam, 3 to 6 percent slopes, except that the depth to coral limestone is 20 to 50 inches. Included in mapping were small areas less than 20 inches deep.

This soil is used for sugarcane, truck crops, and pasture. (Capability classification IIe if irrigated, IVs if nonirrigated; sugarcane group 1; pineapple group 2; pasture group 2)

Ewa cobbly silty clay loam, 0 to 3 percent slopes (EcA).—This soil has a profile like that of Ewa silty clay loam, 3 to 6 percent slopes, except that it is cobbly on the surface. Runoff is very slow, and the erosion hazard is no more than slight.

Most of this soil is used for sugarcane. A small acreage is used for pasture. (Capability classification IIs if irrigated, IVs if nonirrigated; sugarcane group 1; pasture group 2)

Ewa cobbly silty clay loam, 3 to 7 percent slopes (EcB).—This soil has a profile like that of Ewa silty clay loam, 3 to 6 percent slopes, except that it is cobbly on the surface. Included in mapping were a few small, stony areas.

Most of this soil is used for sugarcane. A small acreage is used for pasture. (Capability classification IIe if irrigated, IVs if nonirrigated; sugarcane group 1; pasture group 2)

Ewa silty clay, 0 to 3 percent slopes (EsA).—This soil has a profile like that of Ewa silty clay loam, 3 to 6 percent slopes, except for the texture of the surface layer. Runoff is very slow, and the erosion hazard is no more than slight.

This soil is used for sugarcane. (Capability classification I if irrigated, IVc if nonirrigated; sugarcane group 1; pineapple group 1; pasture group 2)

Ewa silty clay, 3 to 7 percent slopes (EsB).—This soil has a profile like that of Ewa silty clay loam, 3 to 6 percent slopes, except for the texture of the surface layer.

Most of this soil is used for sugarcane. A small acreage is used for pasture. (Capability classification IIe if irrigated, IVc if nonirrigated; sugarcane group 1; pineapple group 2; pasture group 2)

Ewa cobbly silty clay, 3 to 7 percent slopes (EtB).—This soil has a profile like that of Ewa silty clay loam, 3 to 6 percent slopes, except for the texture of the surface layer. Cobblestones in the surface layer interfere with tillage but do not make intertilled crops impracticable.

This soil is used for sugarcane. (Capability classification IIe if irrigated, IVs if nonirrigated; sugarcane group 1; pineapple group 2; pasture group 2)

Ewa stony silty clay, 0 to 2 percent slopes (EwA).—This soil has a profile like that of Ewa silty clay loam, 3 to 6 percent slopes, except for the texture of the surface layer. Surface stones interfere with tillage but do not make intertilled crops impracticable. Runoff is very slow, and the erosion hazard is no more than slight. Included in mapping were a few small areas where the texture of the surface layer is silty clay loam.

This soil is used for sugarcane, truck crops, and pasture. (Capability classification IIs if irrigated, IVs if nonirrigated; sugarcane group 1; pasture group 2)

Ewa stony silty clay, 2 to 6 percent slopes (EwB).—This soil has a profile like that of Ewa silty clay loam, 3 to 6 percent slopes, except for the texture of the surface layer. Stones in the surface layer interfere with tillage, but not enough to make intertilled crops impracticable. Included in mapping were a few small, nonstony areas where the texture of the surface layer is silty clay loam.

This soil is used for sugarcane and pasture. (Capability classification IIe if irrigated, IVs if nonirrigated; sugarcane group 1; pasture group 2)

Ewa stony silty clay, 6 to 12 percent slopes (EwC).—This soil has a profile like that of Ewa silty clay loam, 3 to 6 percent slopes, except for the texture of the surface layer. Surface stones interfere with tillage but do not make intertilled crops impracticable. Runoff is slow to medium, and the erosion hazard is slight to moderate. Included in mapping were small, gently sloping areas.

This soil is used for pasture. (Capability classification IIIe if irrigated, IVe if nonirrigated; sugarcane group 1; pasture group 2)

Fill Land

This land type consists of areas filled with material from dredging, excavation from adjacent uplands, garbage, and bagasse and slurry from sugar mills. The areas are on the islands of Kauai, Maui, and Oahu.

Fill land (Fd).—This land type consists mostly of areas filled with bagasse and slurry from sugar mills. A few areas are filled with material from dredging and from soil excavations. Generally, these materials are dumped and spread over marshes, low-lying areas along the coastal flats, coral sand, coral limestone, or areas shallow to bedrock.

This land type is used mostly for the production of sugarcane. (Not in a capability classification)

Fill land, mixed (Fl).—This land type occurs mostly near Pearl Harbor and in Honolulu, adjacent to the ocean. It consists of areas filled with material dredged from the ocean or hauled from nearby areas, garbage, and general material from other sources. Included in mapping were a few areas that have been excavated.

This land type is used for urban development including airports, housing areas, and industrial facilities. (Not in a capability classification)

Gullied Land

Gullied land (Gl) occurs on the island of Molokai. It is so cut by recent gullies that it is nonarable and the soil profile has been largely destroyed. Erosion is very active, and the soil is bare in many places. Kiawe, ilima, uhaloa, and piligrass provide some protection. Elevations range from nearly sea level to 1,200 feet. The annual rainfall amounts to 20 to 25 inches. This land type is geographically associated with Pamoa, Waikapu, Hoolehua, and Waihuna soils.

Gullied land occurs in the heads of drainageways and on alluvial terraces along the streams. Near the upper margins of the drainageways, almost vertical-sided gullies have cut back into the undisturbed soil areas, leaving remnants of deep soil between gullies. Farther down the slopes, these little spurs are also eroded to varying degrees; at still lower elevations, stones and bedrock are left in the gullies. Slopes on these gulches range from 25 to 70 percent. Where this land type occurs on alluvial terraces, as in the Mahana area of Molokai (fig. 3), there are small tillable areas between gullies. The slope is 3 to 15 percent, and some stones are scattered on the surface. The areas are small and unimportant for cultivation.

This land type is used for pasture. (Capability classification VIIe, nonirrigated)

Haiku Series

This series consists of well-drained soils on uplands on the island of Maui. These soils developed in material weathered from basic igneous rock. They are gently to moderately sloping. Elevations range from nearly sea level to 1,200 feet. The annual rainfall amounts to 50

Figure 3.—Gullied land on alluvial terraces. This land type is in the Mahana area on the island of Molokai.

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to 80 inches. The mean annual soil temperature is 70° F. Haiku soils are geographically associated with Makawao, Paia, and Pauwela soils.

These soils are used for pineapple, pasture, and homesites. The natural vegetation consists of californiagrass, guava, hilograss, lantana, and ricegrass.

Haiku clay, 7 to 15 percent slopes (HbC).—This soil occurs on uplands. Included in mapping were small areas of Paia and Pauwela soils. Also included were small eroded spots and small areas where the slope is as much as 25 percent.

In a representative profile the surface layer is dark-brown clay about 14 inches thick. The subsoil, about 31 inches thick, is yellowish-red, dark reddish-brown, and dark-red clay or silty clay that has subangular and angular blocky structure. The substratum is soft, weathered, basic igneous rock. The soil is very strongly acid in the surface layer and extremely acid and very strongly acid in the subsoil and substratum.

Permeability is moderately rapid. Runoff is slow to medium, and the erosion hazard is slight to moderate. The available water capacity is about 1.4 inches per foot in the surface layer and 1.3 inches per foot in the subsoil. In places roots penetrate to a depth of 3 feet or more.

Representative profile: Island of Maui, lat. 20°54′04″ N. and long. 156°17′36″ W.

Ap1—0 to 7 inches, dark-brown (7.5YR 4/4) clay, light brown (7.5YR 6/4) when dry; strong, fine and very fine, angular blocky structure and strong, medium and fine, granular; slightly hard, firm, sticky and plastic; abundant fine roots; many fine and few coarse pores; many very fine glistening specks; common sand-size aggregates that are resistant to crushing; common worm casts; high bulk density; very strongly acid; gradual, wavy boundary. 6 to 9 inches thick.

Ap2—7 to 14 inches, dark-brown (7.5YR 4/4) clay, light brown (7.5YR 6/4) when dry; strong, fine and very fine, angular blocky structure and strong, medium and fine, granular; slightly hard, firm, sticky and plastic; plentiful roots; common fine and medium pores; many very fine glistening specks; common sand-size aggregates that are resistant to crushing; more firm in place than the Ap1 horizon; common worm casts; high bulk density; thin, massive layer near contact of Ap2 and B21t horizons; very strongly acid; abrupt, wavy boundary. 6 to 10 inches thick.

B21t—14 to 22 inches, yellowish-red (5YR 4/6) clay, yellowish red (5YR 4/8) when dry; weak and moderate, fine and very fine, angular blocky structure; soft, friable, sticky and plastic; few roots; many fine and medium pores; thin, patchy clay films on peds; few sand-size aggregates that are resistant to crushing; extremely acid; gradual, wavy boundary. 5 to 9 inches thick.

B22t—22 to 31 inches, dark reddish-brown (2.5YR 3/4) clay, dark reddish brown (2.5YR 3/4) when dry; moderate, fine and very fine, angular blocky structure; slightly hard, friable, sticky and plastic; few fine roots; many fine pores; thin, patchy clay films on peds; common sand-size aggregates that are resistant to crushing; few pebble-size nodules; very strongly acid; gradual, wavy boundary. 8 to 10 inches thick.

B23t—31 to 39 inches, dark-red (2.5YR 3/6), moist and dry, clay; moderate and strong, medium and fine, angular and subangular blocky structure; slightly hard, firm, sticky and plastic; few fine roots; many fine and medium pores; thin, patchy clay films on peds; many pebble-size gibbsite nodules; very strongly acid; gradual, wavy boundary. 7 to 11 inches thick.

B3—39 to 45 inches, dark-red (2.5YR 3/6) and reddish-brown (5YR 4/4) silty clay, reddish brown (5YR 4/4) when dry; weak, medium and fine, subangular and angular blocky structure; hard, friable, slightly sticky and slightly plastic; few fine roots; many fine pores; thin, patchy clay films on peds; 60 to 80 percent of horizon is very dark brown (10YR 2/2), highly weathered, basic igneous rock that can be easily cut with a knife; very strongly acid; gradual, wavy boundary. 4 to 12 inches thick.

C—45 to 66 inches, very dark brown (10YR 2/2) and dark brown (10YR 3/3) highly weathered basalt with dark-red, continuous, thick coatings that look like oxide coatings on rock surfaces; very little soil material in the rock voids; very strongly acid.

The solum is more than 40 inches thick. The A horizon ranges from 5YR to 7.5YR in hue and, in value, from 3 to 4 when moist and from 3 to 6 when dry. It ranges from 3 to 4 in chroma when moist and from 4 to 6 when dry. The texture of the A horizon is silty clay or clay. The B horizon ranges from 5YR to 2.5YR in hue and from 3 to 4 in value when moist or dry. It ranges from 3 to 6 in chroma when moist and from 3 to 8 when dry.

This soil is used for pineapple, pasture, and homesites. (Capability classification IIIe, irrigated or nonirrigated; pineapple group 6; pasture group 8; woodland group 7)

Haiku clay, 3 to 7 percent slopes (HbB).—On this soil, runoff is slow and the erosion hazard is slight. Included in mapping were small, nearly level areas.

This soil is used for pineapple, pasture, and homesites. (Capability classification IIe, irrigated or nonirrigated; pineapple group 5; pasture group 8; woodland group 7)

Haiku silty clay, 3 to 7 percent slopes (HaB).—This soil has a profile like that of Haiku clay, 7 to 15 percent slopes, except for the texture of the surface layer. Runoff is slow, and the erosion hazard is slight. Included in mapping were small, nearly level areas.

This soil is used for pineapple and homesites. (Capability classification IIe, irrigated or nonirrigated; pineapple group 5; pasture group 8; woodland group 7)

Haiku silty clay, 7 to 15 percent slopes (HaC).—This soil has a profile like that of Haiku clay, 7 to 15 percent slopes, except for the texture of the surface layer.

This soil is used for pineapple. (Capability classification IIIe, irrigated or nonirrigated; pineapple group 6; pasture group 8; woodland group 7)

Halawa Series

This series consists of well-drained soils on uplands on the islands of Maui, Molokai, and Oahu. These soils developed in volcanic ash and in material weathered from basic igneous rock. They are gently sloping to very steep. Elevations range from 500 to 2,000 feet. The annual rainfall amounts to 30 to 60 inches. The mean annual soil temperature is 69° F. Halawa soils are geographically associated with Honolua and Olelo soils.

These soils are used almost entirely for pasture. Small areas are used for pineapple and woodland. The natural vegetation consists of guava, hilograss, kikuyugrass, yellow foxtail, lantana, and brackenfern.

Halawa silty clay, 3 to 25 percent slopes (HlD).—This soil occurs as narrow tracts bounded by gulches. Included in mapping was a tract, about 160 acres in size, of dark-brown soil that is slightly acid throughout the profile. The included area is near Cape Halawa, Molokai, where the rainfall amounts to 25 to 35 inches annually and the elevation is less than 500 feet.

In a representative profile the surface layer is dark reddish-brown silty clay about 11 inches thick. The upper part of the subsoil is reddish-brown silt loam about 5 inches thick. The lower part is dark reddish-brown silty clay, about 28 inches thick, that has subangular blocky structure. The underlying material is silty clay loam over soft, weathered rock. The soil is strongly acid in the surface layer and very strongly acid in the subsoil.

Permeability is moderately rapid. Runoff is slow to medium, and the erosion hazard is slight to moderate. The available water capacity is about 1.2 inches per foot in the surface layer and 1.6 inches per foot in the subsoil. Roots penetrate to a depth of 5 feet or more. Tillage is somewhat difficult because of the slope.

Representative profile: Island of Molokai, lat. 21°7′4″ N. and long. 156°45′47″ W.

Ap—0 to 11 inches, dark reddish-brown (5YR 3/2) silty clay, dark brown (7.5YR 4/2) when dry; strong, very fine and fine, subangular blocky structure; very hard, firm, sticky and plastic; many roots; common, very fine, tubular pores; few wormholes; many glistening specks; high bulk density; strongly acid; abrupt, smooth boundary. 9 to 12 inches thick.

B21—11 to 16 inches, reddish-brown (5YR 4/4) heavy silt loam, dark brown (7.5YR 4/4) when dry; weak, medium and fine, subangular blocky structure; hard, friable, sticky and plastic; many roots; many very fine and fine tubular pores; bulk density is significantly lower than that of Ap horizon; very strongly acid; abrupt, smooth boundary. 4 to 6 inches thick.

IIB22—16 to 26 inches, dark reddish-brown (5YR 3/4), moist and dry, silty clay; moderate, fine and very fine, subangular blocky structure; very hard, firm, sticky and plastic; many roots; many very fine pores; few pockets of friable silty clay loam; very strongly acid; clear, wavy boundary. 9 to 15 inches thick.

IIB23t—26 to 44 inches, dark reddish-brown (2.5YR 3/4 moist, 5 YR 3/3 dry) silty clay; strong, medium, subangular blocky structure breaking to strong, fine and very fine, subangular blocky; very hard, firm, sticky and plastic; many roots; many very fine pores; thin, nearly continuous clay films on ped surfaces; many gritty lumps; very strongly acid; clear, wavy boundary. 11 to 18 inches thick.

IIC1—44 to 58 inches, dark reddish-brown (5YR 3/4) silty clay loam, mottled with red (2.5YR 4/6), strong brown (7.5YR 4/6), and black (10YR 2/1); massive; hard, firm, sticky and plastic; few roots; many pores; very strongly acid. 12 to 16 inches thick.

IIC2—58 inches, very porous saprolite.

The solum ranges from 33 inches to more than 51 inches in thickness. In the A horizon the concentration of heavy minerals is variable. In some areas the bulk density of the A horizon is high, but in others it is negligible. The A horizon ranges from 5YR to 7.5YR in hue, and, when moist, from 2 to 3 in value and chroma. The B horizon ranges from 5YR to 2.5YR in hue. It ranges from 2 to 4 in value and from 3 to 6 in chroma when moist.

This soil is used mainly for pasture. A small acreage is wooded. (Capability classification IVe, irrigated or nonirrigated; pasture group 6; woodland group 5)

Halawa silty clay, 3 to 25 percent slopes, severely eroded (HlD3).—This soil occurs near Kalae, Molokai. Its profile is like that of Halawa silty clay, 3 to 25 percent slopes, except that most of the surface layer and part of the subsoil have been removed by erosion. In many places cultivation has brought weathered rock fragments to the surface. Runoff is medium, and the erosion hazard is moderate to severe.

This soil is used mainly for pasture. Nearly all the acreage was once used for pineapple, but the crop was poorly suited. Only a few small areas are now used for pineapple. (Capability classification VIe, irrigated or nonirrigated; pasture group 6; woodland group 5)

Halawa silt loam, 20 to 35 percent slopes (HJE).—This soil occurs on side slopes of the Waianae Range, between Waialua and Kolekole Pass. It has a profile like that of Halawa silty clay, 3 to 25 percent slopes, except for the texture of the surface layer. Runoff is medium to rapid, and the erosion hazard is moderate to severe. Tillage is difficult because of the slope.

Included in mapping were small areas that have been eroded down to the bedrock. In places there are remnants of a nearly massive subsoil. Also included, at the higher elevations, were very steep to precipitous areas of Rock land and Stony land.

This soil is used for pasture. Pineapple was formerly grown but was poorly suited. (Capability classification VIe, nonirrigated; pasture group 6; woodland group 5)

Halawa silt loam, 35 to 70 percent slopes, eroded (HJF2).—This soil has a profile like that of Halawa silty clay, 3 to 25 percent slopes, except that most of the surface layer and part of the subsoil have been removed by erosion. Runoff is rapid, and the erosion hazard is severe. Included in mapping were a few stony areas.

This soil is used for pasture. Cultivation is impractical, because the soil is too steep. (Capability classification VIIe, nonirrigated; pasture group 6; woodland group 15)

Haleiwa Series

This series consists of well-drained soils on fans and in drainageways along the coastal plains. These soils are on the islands of Oahu and Molokai. They developed in alluvium derived from basic igneous material. They are nearly level to strongly sloping. Elevations range from sea level to 250 feet. The annual rainfall amounts to 30 to 60 inches, most of which occurs between November and April. The mean annual soil temperature is 73° F. Haleiwa soils are geographically associated with Waialua and Kawaihapai soils on Oahu and Kalaupapa soils on Molokai.

These soils are used for sugarcane, truck crops, and pasture. The natural vegetation consists of koa haole, lantana, guava, Christmas berry, bermudagrass, and fingergrass.

Haleiwa silty clay, 0 to 2 percent slopes (HeA).—This soil occurs as large areas on alluvial fans or as long, narrow areas in drainageways. Included in mapping were small areas of poorly drained clayey soils in depressions, as well as small areas of moderately well drained clayey soils.

In a representative profile the surface layer is dark-brown silty clay about 17 inches thick. The subsoil and substratum, to a depth of more than 5 feet, are dark-brown and dark yellowish-brown silty clay that has subangular blocky structure. The soil is neutral to slightly acid.

Permeability is moderate. Runoff is very slow, and the erosion hazard is no more than slight. The available water capacity is about 1.9 inches per foot. In places

roots penetrate to a depth of 5 feet or more. The soil is subject to occasional nondamaging overflow in some places.

Representative profile: Island of Oahu, lat. 21°34′18″ N. and long. 158°03′33″ W.

Ap1—0 to 9 inches, dark-brown (10YR 3/3) silty clay, very dark grayish brown (10YR 3/2) when moist; moderate, fine and medium, granular structure; hard, firm, sticky and plastic; abundant fine, medium, and coarse roots; many, very fine and fine, interstitial pores; moderate effervescence with hydrogen peroxide; slightly acid; gradual, smooth boundary. 4 to 9 inches thick.

Ap2—9 to 17 inches, dark-brown (10YR 3/3) silty clay, very dark grayish brown (10YR 3/2) when moist; moderate, fine, subangular blocky structure; hard, firm, sticky and plastic; abundant very fine and fine, and few coarse roots; common, fine, tubular pores and few, medium, tubular pores; slight effervescence with hydrogen peroxide; slightly acid; clear, wavy boundary. 6 to 9 inches thick.

B2—17 to 26 inches, dark-brown (10YR 3/3), moist and dry, silty clay; weak, fine, subangular blocky structure; hard, firm, sticky and plastic; abundant very fine and fine roots; common, fine, tubular pores and few, medium, tubular pores; patchy, red material that looks like clay films in pores and on some peds; slight effervescence with hydrogen peroxide; neutral; clear, wavy boundary. 8 to 10 inches thick.

C1—26 to 36 inches, dark-brown (10YR 3/3), moist and dry, silty clay; weak, fine, subangular blocky structure; hard, firm, sticky and plastic; plentiful very fine and fine roots; many, very fine, tubular pores; common, medium, tubular pores; few, coarse, tubular pores; moderate effervescence with hydrogen peroxide; neutral; clear, smooth boundary. 8 to 12 inches thick.

C2—36 to 48 inches, dark yellowish-brown (10YR 3/4) silty clay, dark brown (10YR 3/3) when moist; weak, fine, subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; few very fine and medium roots; many, very fine, tubular pores; common, fine, tubular pores; few, medium, tubular pores; slight effervescence on soil mass with hydrogen peroxide; neutral; clear, wavy boundary. 10 to 12 inches thick.

C3—48 to 65 inches, dark yellowish-brown (10YR 3/4) silty clay, dark brown (10YR 3/3) when moist; weak, fine, subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; few very fine roots; many, very fine, tubular pores and few tubular pores; slight effervescence with hydrogen peroxide on stains within pores.

In places the A horizon is silty clay loam or very stony silty clay loam. The solum ranges from 10YR to 7.5YR in hue. A few rounded pebbles occur throughout the profile. In places stones or stratified sand and gravel occur at a depth below 40 inches.

This soil is used for sugarcane, pasture, and truck crops. (Capability classification IIe if irrigated, IIIc if nonirrigated; sugarcane group 1; pasture group 3; woodland group 1)

Haleiwa silty clay, 2 to 6 percent slopes (HeB).—On this soil, runoff is slow and the erosion hazard is slight.

This soil is used for sugarcane, pineapple, and truck crops. (Capability classification IIe if irrigated. IIIc if nonirrigated; sugarcane group 1; pasture group 3; woodland group 1)

Haleiwa silty clay loam, 0 to 10 percent slopes (HcB).—This soil occurs on the Kalaupapa peninsula on Molokai. It has a profile like that of Haleiwa silty clay, 0 to 2 percent slopes, except for the texture of the surface layer and the slope. Runoff is slow to medium, and the erosion hazard is slight. In most places the slope is 3 to 10 percent. In most areas there are a few scattered stones in the surface layer.

This soil is used for pasture. (Capability classification IIIe, irrigated or nonirrigated; sugarcane group 1; pasture group 3; woodland group 1)

Haleiwa very stony silty clay loam, 0 to 15 percent slopes (HdC).—This soil occurs on the Kalaupapa peninsula on Molokai. Runoff is slow to medium, and the erosion hazard is slight to moderate. There are many stones on the surface and in the profile. The stones make cultivation difficult.

This soil is used for pasture. (Capability classification VIs, irrigated or nonirrigated; pasture group 3; woodland group 1)

Halii Series

This series consists of well drained and moderately well drained soils on uplands on the island of Kauai. These soils developed in material weathered from basic igneous rock, probably mixed with volcanic ash and ejecta. They are gently sloping to steep. Elevations range from 300 to 1,000 feet. The annual rainfall amounts to 100 to 200 inches. The mean annual soil temperature is 71° F. Halii soils are geographically associated with Kapaa and Koolau soils.

These soils are used for water supply, wildlife habitat, sugarcane, and pasture. The natural vegetation consists of melastoma, rhodomyrtus, guava, ricegrass, and associated shrubs and grasses.

Halii gravelly silty clay, 3 to 8 percent slopes (HfB).—This soil occurs on ridgetops and side slopes on uplands.

In a representative profile the surface layer is very dark grayish-brown gravelly silty clay about 6 inches thick. The upper part of the subsoil is dark reddish-brown and strong-brown silty clay and clay loam that has subangular blocky structure. Red bands up to 2 inches thick are common. The lower part of the subsoil consists of bands of red clay loam that continue to a depth of more than 60 inches. The substratum is soft, weathered rock. The soil is very strongly acid in the surface layer and very strongly acid to extremely acid in the subsoil.

Permeability is moderately rapid. Runoff is slow, and the erosion hazard is slight. In places roots penetrate to a depth of 5 feet or more.

Representative profile: Island of Kauai, lat. 22°00′32.3″ N. and long. 159°25′54.3″ W.

A11—0 to 3 inches, very dark grayish-brown (10YR 3/2) gravelly silty clay, very dark brown (10YR 2/2) when dry; moderate, fine and very fine, subangular blocky structure; very hard, friable, slightly sticky and slightly plastic; abundant roots; the pebbles and sand grains are of the kind usually called ironstone; soil aggregates tend to harden irreversibly; very strongly acid; clear, smooth boundary. 2 to 5 inches thick.

A12—3 to 6 inches, very dark grayish-brown (10YR 3/2) ironstone gravel and very coarse sand that contains a little clay; single grain; loose; abundant roots; very strongly acid; abrupt, smooth boundary. 2 to 8 inches thick.

B21—6 to 15 inches, strong-brown (7.5YR 4/5) heavy silty clay loam, reddish brown (5YR 4/4) when dry; moderate, medium, subangular blocky structure; soft, friable, sticky and plastic; plentiful roots; common very fine pores; contains numerous hard and soft

pebbles and sand ranging from 1 millimeter to several centimeters in diameter; peds have nearly continuous coatings that look like clay films; extremely acid; abrupt, wavy boundary. 8 to 12 inches thick.

B22 15 to 18 inches, dark reddish-brown (5YR 3/3) silty clay, reddish brown (5YR 4/4) and dark reddish brown (5YR 3/3) when dry; moderate, medium and fine, subangular blocky structure; slightly hard, friable, sticky and plastic; few roots; common fine and very fine pores; 10 to 15 percent weathered rock fragments that are cemented and cannot be broken in the hand; numerous patchy coatings that look like clay films, nearly continuous in places; extremely acid; abrupt, wavy boundary. 3 to 8 inches thick.

B23—18 to 24 inches, dark reddish-brown (5YR 3/2) clay loam; common, fine, distinct mottles of strong brown (7.5YR 5/6), dark brown (7.5YR 4/4) when dry; weak, coarse and medium, subangular blocky structure; slightly hard, friable, sticky and plastic; very few very fine roots; common patchy coatings that look like clay films on all ped surfaces and in pores; very strongly acid; abrupt, wavy boundary. 6 to 10 inches thick.

B24—24 to 31 inches, bands of red (2.5YR 4/6) clay loam, reddish brown (5YR 4/3) and dark brown (7.5YR 3/2 and 7.5YR 3/4) when dry; common, fine, distinct mottles of strong brown (7.5YR 5/6); weak, coarse, subangular blocky structure; slightly hard, friable, sticky and plastic; very few very fine roots; common very fine, fine, and medium pores; common, thin, patchy coatings that look like clay films on all ped surfaces; very strongly acid; abrupt, wavy boundary. 4 to 10 inches thick.

B25—31 to 60 inches, three red layers with interlayered dark-brown horizons of material like that of the B24 horizon; very few very fine roots; common very fine, fine, and medium pores; few to common patchy coatings that look like clay films; very strongly acid. 20 to 30 inches thick.

The A horizon ranges from gravelly silty clay loam to gravelly silty clay in texture. It ranges from 7.5YR to 2.5Y in hue. The B horizon ranges from 2.5YR to 7.5YR in hue, from 3 to 5 in value, and from 2 to 6 in chroma.

This soil is used for sugarcane, wildlife habitat, and water supply. (Capability classification IVs, nonirrigated; sugarcane group 2; pineapple group 7; pasture group 10; woodland group 9)

Halii gravelly silty clay, 8 to 15 percent slopes (HfC).—On this soil, runoff is slow and the erosion hazard is slight to moderate.

This soil is used for sugarcane, wildlife habitat, and water supply. (Capability classification IVe, nonirrigated; sugarcane group 2; pineapple group 8; pasture group 10; woodland group 9)

Halii gravelly silty clay, 15 to 25 percent slopes, eroded (HfD2).—This soil is similar to Halii gravelly silty clay, 3 to 8 percent slopes, except that most of the surface layer has been removed by erosion. Runoff is medium, and the erosion hazard is moderate.

This soil is used for water supply, wildlife habitat, pasture, and sugarcane. (Capability classification IVe, nonirrigated; sugarcane group 2; pasture group 10; woodland group 9)

Halii gravelly silty clay, 25 to 40 percent slopes, eroded (HfE2).—The surface layer and the upper part of the subsoil have been removed by erosion. Runoff is rapid, and the erosion hazard is severe. Included in mapping were small areas where the slope is less than 25 percent or more than 40 percent.

This soil is used for water supply and wildlife habitat. (Capability classification VIe, nonirrigated; pasture group 10; woodland group 9)

Haliimaile Series

This series consists of well-drained soils on uplands on the island of Maui. These soils developed in material weathered from basic igneous rock. They are gently to strongly sloping. Elevations range from 500 to 2,000 feet. The annual rainfall amounts to 30 to 50 inches. The mean annual soil temperature is 71° F. Haliimaile soils are geographically associated with Hamakuapoko, Keahua, Paia, and Pane soils.

These soils are used for sugarcane, pineapple, pasture, and homesites. The natural vegetation consists of guava, indigo, koa haole, lantana, Natal redtop, and yellow foxtail.

Haliimaile silty clay, 3 to 7 percent slopes (HhB).—This soil is on smooth uplands. Included in mapping were small areas of Keahua and Paia soils.

In a representative profile the surface layer is dark reddish-brown silty clay about 15 inches thick. The subsoil, to a depth of more than 60 inches, is dark reddish-brown silty clay and very dark grayish-brown clay. It has subangular blocky and angular blocky structure. The substratum is solt, weathered basic igneous rock. The soil is strongly acid in the surface layer and strongly acid to medium acid in the subsoil.

Permeability is moderately rapid. Runoff is slow, and the erosion hazard is slight. The available water capacity is about 1.6 inches per foot in the surface layer and about 1.2 inches per foot in the subsoil. In places roots penetrate to a depth of 5 feet or more.

Representative profile: Island of Maui, lat. 20°51′08″ N. and long. 156°21′24″ W.

Ap—0 to 15 inches, dark reddish-brown (5YR 3/3 moist, 5YR 3/4 dry) silty clay; moderate, fine and very fine, granular structure; hard, friable, sticky and plastic; abundant roots; many fine pores; common, small, black concretions; few weathered rock fragments; strong effervescence with hydrogen peroxide; strongly acid; clear, smooth boundary. 12 to 18 inches thick.

B21—15 to 27 inches, dark reddish-brown (5YR 3/3 moist, 5YR 3/4 dry) silty clay; moderate, medium and fine, subangular blocky structure; hard, friable, sticky and plastic; few roots; many fine and very fine pores; patchy pressure cutans; common, small, black concretions; strong effervescence with hydrogen peroxide; strongly acid; clear, wavy boundary, 12 to 18 inches thick.

B22—27 to 41 inches, dark reddish-brown (5YR 3/3 moist, 5YR 3/4 dry) silty clay; moderate, medium and fine, subangular blocky structure; hard, friable, sticky and plastic; few roots; many fine and very fine pores; patchy pressure cutans; few very fine rock fragments; common, small, black concretions; strong effervescence with hydrogen peroxide; strongly acid; abrupt, wavy boundary. 12 to 16 inches thick.

IIB3—41 to 65 inches, very dark grayish-brown (10YR 3/2) clay, dark gray (10YR 4/1) when dry; strong, fine and very fine, angular blocky structure; hard, firm, very sticky and very plastic; few roots; many fine and very fine pores; patchy pressure cutans; many highly weathered rock fragments; slight effervescence with hydrogen peroxide; medium acid.

The thickness of the solum is more than 60 inches. A little gravel and a few cobblestones occur in some places. The A

horizon ranges from 5YR to 7.5YR in hue, from 2 to 3 in value when moist or dry, and from 2 to 3 in chroma when moist and 2 to 4 when dry. The texture of the A horizon is generally silty clay, but in places it is silty clay loam or gravelly silty clay. The B2 horizon ranges from 5YR to 7.5YR in hue, from 3 to 4 in value when dry, and from 2 to 3 in chroma when moist and 2 to 4 when dry. The texture of the B2 horizon is silty clay or clay.

This soil is used for sugarcane, pineapple, and homesites. (Capability classification IIe, irrigated or nonirrigated; sugarcane group 1; pineapple group 5; pasture group 3; woodland group 1)

Haliimaile silty clay, 7 to 15 percent slopes (HhC).—On this soil, runoff is medium and the erosion hazard is moderate. Included in mapping were small, cobbly areas and small, moderately steep areas.

This soil is used for sugarcane, pineapple, and homesites. (Capability classification IIIe, irrigated or nonirrigated; sugarcane group 1; pineapple group 6; pasture group 3; woodland group 1)

Haliimaile gravelly silty clay, 7 to 15 percent slopes, eroded (HkC2).—This soil has a profile like that of Haliimaile silty clay, 3 to 7 percent slopes, except that in most places about 50 percent of the original surface layer has been lost through erosion. In a few places all the surface layer and part of the subsoil have been removed. Runoff is medium to rapid, and the erosion hazard is severe.

This soil is used for pineapple and pasture. (Capability classification IVe, irrigated or nonirrigated; sugarcane group 1; pineapple group 6; pasture group 3; woodland group 1)

Haliimaile silty clay loam, 3 to 7 percent slopes (HgB).—This soil has a profile like that of Haliimaile silty clay, 3 to 7 percent slopes, except for the texture of the surface layer. Included in mapping were small eroded areas on knolls. The surface layer of the included areas contains few to many pebble-size rock fragments.

This soil is used for pineapple, pasture, and homesites. (Capability classification IIe, irrigated or nonirrigated; sugarcane group 1; pineapple group 5; pasture group 3; woodland group 1)

Haliimaile silty clay loam, 7 to 15 percent slopes (HgC).—This soil has a profile like that of Haliimaile silty clay, 3 to 7 percent slopes, except for the texture of the surface layer. Runoff is medium, and the erosion hazard is moderate. Included in mapping were small eroded areas on knolls. The surface layer of the included areas contains few to many pebble-size rock fragments.

This soil is used for pineapple, pasture, and homesites. (Capability classification IIIe, irrigated or nonirrigated; sugarcane group 1; pineapple group 6; pasture group 3; woodland group 1)

Hamakuapoko Series

This series consists of well-drained soils on uplands on the island of Maui. These soils developed in material weathered from basic igneous rock. They are gently to strongly sloping. Elevations range from 500 to 1,200 feet. The annual rainfall amounts to 40 to 60 inches. The mean annual soil temperature is 71° F. Hamakuapoko soils are geographically associated with Haiku, Haliimaile, and Paia soils.

These soils are used for pineapple, pasture, and homesites. The natural vegetation consists of Christmas berry, guava, hilograss, and yellow foxtail.

Hamakuapoko silty clay, 3 to 7 percent slopes (HlB).—This soil is on smooth slopes in the uplands. Included in mapping were small areas of Haiku and Haliimaile soils. Also included were small, moderately steep areas.

In a representative profile the surface layer is dark-brown silty clay about 16 inches thick. The subsoil, about 35 inches thick, is dark-brown and very dark grayish-brown silty clay that has subangular blocky structure. The substratum is soft, weathered basic igneous rock. The soil is extremely acid in the surface layer and strongly acid or very strongly acid in the subsoil.

Permeability is moderately rapid. Runoff is slow, and the erosion hazard is slight. The available water capacity is about 1.2 inches per foot in the surface layer and 1.5 inches per foot in the subsoil. In places roots penetrate to a depth of 4 feet or more.

Representative profile: Island of Maui, lat. 20°52′52″ N. and long. 156°14′52″ W.

Ap1—0 to 10 inches, dark-brown (10YR 3/3) silty clay, dark grayish brown (10YR 4/2) when dry; moderate, medium and fine, subangular blocky structure; hard, firm, very sticky and very plastic; plentiful roots; many fine pores; common sand-size aggregates that are resistant to crushing; high bulk density; extremely acid; gradual, wavy boundary. 8 to 12 inches thick.

Ap2—10 to 16 inches, dark-brown (10YR 3/3) silty clay, brown (10YR 4/3) when dry; moderate, fine and very fine, subangular blocky structure; hard, firm, very sticky and very plastic; plentiful roots; common fine and medium pores; common sand-size aggregates that are resistant to crushing; high bulk density; very strongly acid; clear, wavy boundary. 4 to 8 inches thick.

B21—16 to 21 inches, dark-brown (7.5YR 3/2) silty clay, brown (7.5YR 4/2) when dry; moderate, fine and very fine, subangular blocky structure; hard, friable, sticky and plastic; few roots; many fine and very fine pores; strongly acid; clear, wavy boundary. 3 to 7 inches thick.

B22t—21 to 38 inches, dark-brown (7.5YR 3/2) silty clay, brown (7.5YR 4/2) when dry; strong, fine and very fine, subangular blocky structure; hard, firm, very sticky and plastic; few roots; many fine and very fine pores; nearly continuous, moderately thick clay films; common sand-size aggregates that are resistant to crushing; very strongly acid; gradual, wavy boundary. 16 to 20 inches thick.

B3—38 to 51 inches, very dark grayish-brown (10YR 3/2) silty clay, brown (10YR 4/3) when dry; moderate, fine and very fine, subangular blocky structure; hard, friable, sticky and plastic; few roots; common fine and very fine pores; thin, patchy clay films; 15 to 20 percent highly weathered gravel and cobblestones; very strongly acid.

The solum is more than 40 inches thick. The A horizon ranges from 2 to 3 in value when moist, and from 2 to 3 in chroma when moist or dry. The Bt horizon ranges from 2 to 3 in value when moist and from 2 to 3 in chroma when moist or dry. The texture of the Bt horizon ranges from silty clay to clay.

Most of this soil is used for pineapple. A small acreage is used for pasture. (Capability classification IIe, irrigated or nonirrigated; pineapple group 5; pasture group 6; woodland group 5)

Hamakuapoko silty clay, 7 to 15 percent slopes (HIC).—On this soil, runoff is medium and the erosion hazard is moderate.

Most of this soil is used for pineapple. A small acreage is used for pasture and homesites. (Capability classification IIIe, irrigated or nonirrigated; pineapple group 6; pasture group 6; woodland group 5)

Hamakuapoko silty clay, 7 to 15 percent slopes, eroded (HIC2).—This soil has a profile like that of Hamakuapoko silty clay, 3 to 7 percent slopes, except that it is eroded. In most places about 50 percent of the original surface layer has been removed by erosion. In a few places all of the surface layer and part of the subsoil have been lost. Runoff is medium to rapid, and the erosion hazard is severe.

This soil is used for pineapple. (Capability classification IVe, irrigated or nonirrigated; pineapple group 6; pasture group 6; woodland group 5)

Hana Series

This series consists of well-drained soils on uplands on the island of Maui. These soils developed in volcanic ash. They are gently sloping to moderately steep. Elevations range from nearly sea level to 1,200 feet. The annual rainfall amounts to 80 to 150 inches. It is well distributed throughout the year. The mean annual soil temperature is 73° F. Hana soils are geographically associated with Honomanu and Malama soils.

In this survey area moderately deep variants of the Hana series were mapped. These soils, Hana silty clay loam, moderately deep variant, 3 to 15 percent slopes, and Hana extremely stony silty clay loam, moderately deep variant, 3 to 15 percent slopes, are described in alphabetical order, along with other units of this series.

These soils are used for pasture and homesites. The natural vegetation consists of californiagrass, guava, kaimiclover, koa, and sedges.

Hana very stony silty clay loam, 3 to 25 percent slopes (HKLD).—This soil is on smooth, low mountain slopes. Included in mapping were small areas of Honomanu soils. Also included were small, steep areas near cinder cones.

In a representative profile the surface layer is very dark brown and very dark grayish-brown silty clay loam about 12 inches thick. The subsoil, about 22 inches thick, is dark-brown silty clay loam that has subangular blocky structure. The substratum is moderately weathered, pebble-size cinders overlying Aa lava. The soil is strongly acid to medium acid in the surface layer and slightly acid in the subsoil.

Permeability is moderately rapid. Runoff is slow to medium, and the erosion hazard is slight to moderate. In places roots penetrate to a depth of 3 to 4 feet. The available water capacity is about 1.2 inches per foot in the surface layer and 1.4 inches per foot in the subsoil.

Representative profile: Island of Maui, lat. 20°47′14″ N. and long. 156°02′04″ W.

Ap—0 to 7 inches, very dark brown (10YR 2/2, moist) very stony silty clay loam; strong, very fine and fine, subangular blocky structure; very hard, friable, slightly sticky and slightly plastic, and moderately smeary; abundant very fine and fine roots; many fine pores; common worm casts; stones cover 1 to 3 percent of the surface; strongly acid; gradual, smooth boundary. 6 to 9 inches thick.

A1—7 to 12 inches, very dark grayish-brown (10YR 3/2, moist) silty clay loam; strong, very fine and fine, subangular blocky structure; very hard, friable, slightly sticky and slightly plastic, and moderately smeary; abundant very fine and fine roots; many fine pores; few worm casts; common, moderately weathered, fine cinders; medium acid; clear, wavy boundary. 4 to 6 inches thick.

B21—12 to 20 inches, dark-brown (7.5YR 3/2, moist) silty clay loam; moderate, medium and fine, subangular blocky structure; very hard, friable, sticky and plastic, and moderately smeary; abundant very fine and fine roots; many fine pores; common, fine, red, weathered cinders; slightly acid; gradual, wavy boundary. 7 to 12 inches thick.

B22—20 to 34 inches, dark-brown (7.5YR 3/2, moist) silty clay loam; moderate, fine and medium, subangular blocky structure; hard, very friable, slightly sticky and slightly plastic, and moderately smeary; abundant very fine and fine roots; many fine and medium pores; 5 percent hard rock fragments; slightly acid; abrupt, wavy boundary. 10 to 20 inches thick.

IIC—34 inches, red and grayish-brown moderately weathered, pebble-size cinders over Aa lava.

The depth to cinders and Aa lava ranges from 34 to 48 inches. In places stones cover as much as 3 percent of the surface. The A horizon ranges from 7.5YR to 10YR in hue and from 2 to 3 in value and chroma. The B horizon ranges from 5YR to 10YR in hue and from 2 to 4 in value and chroma. The B horizon hardens irreversibly into black and brown, sharp, angular, very hard, fine, pebble-size aggregates.

This soil is used for pasture. (Capability classification VIs, nonirrigated; pasture group 11; woodland group 8)

Hana extremely stony silty clay loam, 3 to 25 percent slopes (HKMD).—This soil has a profile like that of Hana very stony silty clay loam, 3 to 25 percent slopes, except that stones cover 3 to 15 percent of the surface. Workability is very difficult. Included in mapping were small, steep areas near cinder cones.

This soil is used for pasture. (Capability classification VIs, nonirrigated; pasture group 11; woodland group 8)

Hana silty clay loam, moderately deep variant, 3 to 15 percent slopes (HKNC).—This soil is nonstony and moderately deep. Its surface layer is dark-brown silty clay loam that contains 10 to 15 percent gravel and cobblestones. The subsoil, 6 to 14 inches thick, is reddish-brown, very friable silty clay loam that has weak, subangular blocky structure. It contains 20 to 30 percent gravel and cobblestones. The substratum is fragmental Aa lava at a depth of 20 to 30 inches.

Runoff is slow to medium, and the erosion hazard is slight to moderate. In places roots penetrate to a depth of 2 to 3 feet. Included in mapping were small, moderately steep and steep areas near cinder cones. Also included were a few rock outcrops.

This soil is used for pasture and homesites. (Capability classification IIIe, nonirrigated; pasture group 11; woodland group 8)

Hana extremely stony silty clay loam, moderately deep variant, 3 to 15 percent slopes (HKOC).—This soil has a profile like that of Hana silty clay loam, moderately deep variant, 3 to 15 percent slopes, except that stones cover 3 to 15 percent of the surface. Workability is very difficult. Included in mapping were small, moderately steep and steep areas near cinder cones.

This soil is used for pasture. (Capability classification VIs, nonirrigated; pasture group 9; woodland group 8)

Hanalei Series

This series consists of somewhat poorly drained to poorly drained soils on bottom lands on the islands of Kauai and Oahu. These soils developed in alluvium derived from basic igneous rock. They are level to gently sloping. Elevations range from nearly sea level to 300 feet. The annual rainfall amounts to 20 to 120 inches. The mean annual soil temperature is 74° F. Hanalei soils are geographically associated with Haleiwa, Hihimanu, Mokuleia, and Pearl Harbor soils.

These soils are used for taro, pasture, sugarcane, and vegetables. The natural vegetation consists of paragrass, sensitiveplant, honohono, Java plum, and guava.

Hanalei silty clay, 0 to 2 percent slopes (HnA).—This soil is on stream bottoms and flood plains. Included in the areas mapped on Kauai along the Waimea River and in Waipaoiki Valley are small areas where the surface layer is 8 to 10 inches of reddish-brown silty clay. Included in the areas mapped on Oahu were small areas of very deep, well-drained alluvial soils and small areas of very poorly drained to poorly drained clay soils that are strongly mottled and are underlain by peat, muck, or massive marine clay.

In a representative profile the surface layer, about 10 inches thick, is dark-gray and very dark gray silty clay that has dark-brown and reddish mottles. The subsurface layer is very dark gray and dark-gray silty clay about 3 inches thick. The subsoil, about 13 inches thick, is mottled, dark-gray and dark grayish-brown silty clay loam that has angular blocky structure. The substratum is stratified alluvium. The soil is strongly acid to very strongly acid in the surface layer and neutral in the subsoil.

Permeability is moderate. Runoff is very slow, and the erosion hazard is no more than slight. The available moisture capacity is about 2.1 inches per foot of soil. Roots penetrate to the water table. Flooding is a hazard.

Representative profile: Island of Kauai, lat. 22°12′37.8″ N. and long. 159°28′47″ W.

Ap—0 to 6 inches, dark-gray (10YR 4/1) silty clay; common distinct mottles of dark brown (7.5YR 4/4), red (2.5YR 5/6), and dark reddish brown (5YR 3/4); weak, coarse and medium, granular structure; very hard, friable, sticky and plastic; abundant fine and medium roots; many fine and medium pores; very strongly acid; abrupt, wavy boundary. 4 to 6 inches thick.

A1g—6 to 10 inches, very dark gray (10YR 3/1) silty clay; many distinct mottles of dark reddish brown (5YR 3/4), yellowish red (5YR 4/6), dark brown (7.5YR 4/4), and dark grayish brown (10YR 4/2); weak, coarse, prismatic structure; very hard, firm, sticky and plastic; abundant fine and medium roots; common fine and medium pores; strongly acid; gradual, smooth boundary. 3 to 5 inches thick.

A3g—10 to 13 inches, mixed, very dark gray (10YR 3/1) and dark gray (10YR 4/1) silty clay; many distinct mottles of yellowish red (5YR 4/6) and dark reddish brown (2.5YR 3/4); weak, coarse, prismatic structure; very hard, firm, sticky and plastic; common medium and fine roots; many fine and medium pores; slightly acid; gradual, smooth boundary. 2 to 4 inches thick.

B21g—13 to 18 inches, mixed, dark-gray (10YR 4/1) and dark grayish-brown (10YR 4/2) silty clay loam; many distinct mottles of strong brown and dark red (2.5YR 3/6); massive, but a few pockets have weak, medium, angular blocky structure; hard, firm, sticky and plastic; few medium and fine roots; many fine and medium pores; neutral; gradual, smooth boundary. 4 to 7 inches thick.

B22g—18 to 26 inches, dark grayish-brown (10YR 4/2) silty clay loam; many distinct mottles of dark red (2.5YR 3/6) and strong brown (7.5YR 5/6); weak, coarse, prismatic structure breaking to weak, fine and medium, angular blocky; slightly hard, firm, sticky and plastic; few medium and fine roots; many fine and medium pores; neutral; gradual, smooth boundary. 7 to 9 inches thick.

C—26 to 36 inches, dark grayish-brown (10YR 4/2) silty clay loam; common distinct mottles of strong brown (7.5YR 5/6), dark red (2.5YR 3/6), and red (2.5YR 4/6); massive; slightly hard, friable, sticky and plastic; few medium roots; many, fine and medium, tubular pores; slightly acid; water stands above this layer.

The A horizon ranges from 10YR to 2.5Y in hue, from 3 to 4 in value, and from 1 to 2 in chroma. Mottles range from a few faint ones to many distinct ones. The B horizon ranges from 10YR to 2.5Y in hue, from 2 to 4 in value, and from 1 to 2 in chroma. Mottles in the B and C horizons range from few to many. The depth to the seasonal high water table ranges from 2 to 5 feet. The C horizon is stratified. It ranges from silty clay to sand in texture.

This soil is used for taro, pasture, and sugarcane. (Capability classification IIw, irrigated or nonirrigated; sugarcane group 3; pasture group 7; woodland group 4)

Hanalei silty clay, 2 to 6 percent slopes (HnB).—On this soil, runoff is slow and the erosion hazard is slight.

This soil is used for sugarcane, taro, and pasture. (Capability classification IIw, irrigated or nonirrigated; sugarcane group 3; pasture group 7; woodland group 4)

Hanalei stony silty clay, 2 to 6 percent slopes (HoB).—This soil has a profile like that of Hanalei silty clay, 0 to 2 percent slopes, except that it is stony. Runoff is slow, and the erosion hazard is slight. Stones hinder machine cultivation.

This soil is used for sugarcane and pasture. (Capability classification IIw, irrigated or nonirrigated; sugarcane group 3; pasture group 7; woodland group 4)

Hanalei silty clay, deep water table, 0 to 6 percent slopes (HrB).—This soil has a profile like that of Hanalei silty clay, 0 to 2 percent slopes, except that it has fewer mottles and the water table is at a depth of more than 3 feet. Included in mapping were small areas of stony soils.

This soil is used for sugarcane, taro, pasture, and vegetables. (Capability classification IIw, irrigated or nonirrigated; sugarcane group 3; pasture group 7; woodland group 4)

Hanalei silty clay loam, 0 to 2 percent slopes (HmA).—This soil has a profile like that of Hanalei silty clay, 0 to 2 percent slopes, except for the texture of the surface layer. Also, this soil is underlain by sand at a depth of 30 to 50 inches. Included in mapping was an area on the Hanalei River bottom that is less than 30 inches deep over sand.

This soil is used for taro, pasture, and sugarcane. (Capability classification IIw, irrigated or nonirrigated; sugarcane group 3; pasture group 7; woodland group 4)

Hanalei peaty silty clay loam, 0 to 2 percent slopes (HpA).—This soil has a profile like that of Hanalei silty clay, 0 to 2 percent slopes, except for the texture of the surface layer. Also, the water table is at the surface.

This soil is used for pasture. (Capability classification IVw, irrigated or nonirrigated; sugarcane group 3; pasture group 7; woodland group 4)

Hanamaulu Series

This series consists of well-drained soils on stream terraces and steep terrace breaks on the island of Kauai. These soils developed in alluvium washed from upland soils. They are nearly level to strongly sloping. Elevations range from 200 to 700 feet. The annual rainfall amounts to 60 to 100 inches. The mean annual soil temperature is 73° F. Hanamaulu soils are geographically associated with Kapaa and Hihimanu soils.

These soils are used for sugarcane, pasture, wildlife habitat, and water supply. The natural vegetation consists of guava, pandanus, glenwoodgrass, ricegrass, hau, and mango.

Hanamaulu silty clay, 3 to 8 percent slopes (HsB).—This soil is on terraces. Included in mapping were two areas of stony soil adjacent to streams.

In a representative profile the surface layer is brown and very dark grayish-brown silty clay about 11 inches thick. The subsoil, about 60 inches thick, is dark-brown and dark reddish-brown subangular blocky silty clay over silty clay loam. The substratum consists of slightly to strongly weathered pebbles, stones, and boulders. The soil is extremely acid in the surface layer and very strongly acid in the subsoil.

Permeability is moderately rapid. Runoff is slow, and the erosion hazard is no more than slight. The available moisture capacity is about 1.4 inches per foot of soil. In places roots penetrate to a depth of 5 feet or more.

Representative profile: Island of Kauai, lat. 22°02′26.5″ N. and long. 159°23′59.3″ W.

Ap1—0 to 5 inches, very dark grayish-brown (10YR 3/2) silty clay, very dark grayish brown (2.5Y 3/2) when dry; moderate, medium and fine, granular structure; hard, firm, sticky and plastic; many roots; slight effervescence with hydrogen peroxide; some material from Ap2 horizon mixed by plowing; extremely acid; abrupt, smooth boundary. 5 to 7 inches thick.

Ap2—5 to 11 inches, dark-brown (7.5YR 3/4) silty clay, brown (7.5YR 4/3) when dry; weak, fine and very fine, subangular blocky structure; hard, firm, sticky and plastic; plentiful fine and very fine roots; many fine and very fine pores; slight effervescence with hydrogen peroxide; some material from B21 horizon mixed by plowing; very strongly acid; clear, smooth boundary. 6 to 7 inches thick.

B21—11 to 20 inches, dark reddish-brown (5YR 3/3) silty clay, dark reddish brown (5YR 3/4) when dry; strong, very fine, subangular blocky structure; hard, firm, sticky and plastic; plentiful fine and very fine roots; common fine and many very fine pores; many moderately thick coatings on ped faces and in pores; coatings look like clay films; strongly acid; gradual, smooth boundary. 7 to 10 inches thick.

B22—20 to 36 inches, dark reddish-brown (5YR 3/4), moist and dry, silty clay; strong, very fine, subangular blocky structure; very hard, firm, sticky and plastic; plentiful fine and few very fine roots; few fine and many very fine pores; continuous, moderately thick coatings on ped faces and in pores; coatings look like clay films; very strongly acid; gradual, smooth boundary. 12 to 21 inches thick.

B23—36 to 54 inches, dark-brown (7.5YR 3/4), moist and dry, silty clay loam; strong, very fine, subangular blocky structure; very hard, firm, slightly sticky and slightly plastic; few fine and very fine roots; few fine and many very fine pores; continuous, moderately thick coatings on ped faces and in pores; coatings look like clay films; pore coatings are strong brown (7.5YR 4/6); very strongly acid; gradual, smooth boundary. 12 to 22 inches thick.

B24—54 to 61 inches, dark-brown (7.5YR 3/4), moist and dry, silty clay loam; moderate, very fine, subangular blocky structure; very hard, firm, slightly sticky and slightly plastic; few fine and very fine roots; few fine and many very fine pores; continuous, moderately thick coatings on ped faces and in pores; coatings look like clay films; some pores coated with strong brown (7.5YR 4/6); very strongly acid; gradual, smooth boundary. 12 to 21 inches thick.

B3—61 to 72 inches, dark-brown (7.5YR 3/4) clay loam; 1/10-inch bands and pockets of yellowish red (5YR 3/6) and coatings and segregations of strong brown (7.5YR 5/6); weak, fine, subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; few fine and very fine roots; few fine and very fine pores; few thin coatings that look like clay films; under a 10-power hand lens, the soil material has a sugary appearance; strongly acid.

The A horizon ranges from 7.5YR to 2.5Y in hue, and the B horizon from 5YR to 7.5YR. The depth to the underlying pebbles, stones, and boulders ranges from 3 feet to more than 6 feet.

This soil is used for sugarcane, pasture, water supply, and wildlife habitat. (Capability classification IIe, irrigated or nonirrigated; sugarcane group 2; pasture group 8; woodland group 7)

Hanamaulu silty clay, 8 to 15 percent slopes (HsC).—On this soil, runoff is slow to medium and the erosion hazard is slight. Included in mapping were some areas that have a dark reddish-brown surface layer.

This soil is used for sugarcane, pasture, water supply, and wildlife habitat. (Capability classification IIIe, irrigated or nonirrigated; sugarcane group 2; pasture group 8; woodland group 7)

Hanamaulu silty clay, 15 to 25 percent slopes (HsD).—On this soil, runoff is medium and the erosion hazard is moderate. Included in mapping were some areas that have a dark reddish-brown surface layer.

This soil is used for sugarcane, pasture, water supply, and wildlife habitat. (Capability classification IVe, irrigated or nonirrigated; sugarcane group 2; pasture group 8; woodland group 7)

Hanamaulu silty clay, 25 to 40 percent slopes (HsE).—On this soil, runoff is rapid and the erosion hazard is moderate to severe. Included in mapping were some areas that have a dark reddish-brown surface layer.

This soil is used for pasture, woodland, water supply, and wildlife habitat. (Capability classification VIe, nonirrigated; pasture group 8; woodland group 7)

Hanamaulu stony silty clay, 10 to 35 percent slopes (HtE).—This soil has a profile like that of Hanamaulu silty clay, 3 to 8 percent slopes, except that it is stony and the slope is as much as 35 percent. The stones interfere with the operation of farm machinery. Runoff is medium to rapid, and the erosion hazard is moderate to severe. Included in mapping were some areas that have a dark reddish-brown surface layer.

This soil is used for pasture, woodland, wildlife habitat, and water supply. (Capability classification VIe, nonirrigated; pasture group 8; woodland group 7)

Hanamaulu bouldery silty clay, 10 to 35 percent slopes (HuE).—This soil has a profile like that of Hanamaulu silty clay, 3 to 8 percent slopes, except for the

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boulders, which make the use of farm machinery for land preparation and planting impractical. Runoff is medium to rapid, and the erosion hazard is moderate to severe. Included in mapping were some areas that have a dark reddish-brown surface layer.

This soil is used for pasture, woodland, wildlife habitat, and water supply. (Capability classification VIe, nonirrigated; pasture group 8; woodland group 7)

Helemano Series

This series consists of well-drained soils on alluvial fans and colluvial slopes on the sides of gulches. These soils are on the island of Oahu. They developed in alluvium and colluvium derived from basic igneous rock. They are steep to extremely steep. Elevations range from 500 to 1,200 feet. The annual rainfall dominantly amounts to 30 to 60 inches but ranges to 75 inches at the highest elevations. The mean annual soil temperature is 72° F. Helemano soils are geographically associated with Lahaina, Leilehua, Manana, Molokai, and Wahiawa soils.

These soils are used for pasture, woodland, and wildlife habitat. The natural vegetation consists of bermudagrass, Christmas berry, eucalyptus, Formosa koa, guava, Japanese tea, Java plum, and koa haole.

Helemano silty clay, 30 to 90 percent slopes (HLMG).—This soil is on the sides of V-shaped gulches. Included in mapping were small areas of Lahaina and Molokai soils. Also included were small areas of rock outcrop, steep stony land, and eroded spots.

In a representative profile the surface layer is dark reddish-brown silty clay about 10 inches thick. The subsoil, about 50 inches thick, is dark reddish-brown and dark-red silty clay that has subangular blocky structure. The substratum is soft, highly weathered basic igneous rock. The soil is neutral in the surface layer and neutral to slightly acid in the subsoil.

Permeability is moderately rapid. Runoff is medium to very rapid, and the erosion hazard is severe to very severe.

Representative profile: Island of Oahu, lat. 21°27′47″ N. and long. 157°59′59″ W.

Ap—0 to 10 inches, dark reddish-brown (2.5YR 3/4), moist and dry, silty clay; moderate, very fine and fine, granular structure; hard, firm, sticky and plastic; abundant roots; many, very fine, interstitial pores; neutral in reaction; abrupt, smooth boundary. 6 to 10 inches thick.

B21—10 to 30 inches, dark reddish-brown (2.5YR 3/4) silty clay, dark red (2.5YR 3/6) when dry; moderate, fine, subangular blocky structure; hard, friable, sticky and plastic; plentiful roots; common, fine, tubular pores; 5 to 10 percent gravel and stones; neutral; clear, smooth boundary. 12 to 20 inches thick.

B22—30 to 41 inches, dark reddish-brown (2.5YR 3/4), moist and dry, silty clay; moderate, fine and medium, subangular blocky structure; hard, friable, sticky and plastic; few fine roots; common, fine, tubular pores; 15 to 25 percent soft, strongly weathered gravel and stones; neutral; gradual, smooth boundary. 8 to 12 inches thick.

B3—41 to 60 inches, dark-red (10YR 3/6) silty clay, red (10YR 4/6) when dry; moderate, fine and very fine, subangular blocky structure; hard, friable, sticky and plastic; few very fine roots; common, fine and medium, tubular pores; 25 to 50 percent soft, strongly weathered gravel and stones; slightly acid. 10 to 20 inches thick.

The depth to highly weathered rock is variable but ranges from 25 to more than 60 inches. Near the toe of slopes, the soil is commonly more than 60 inches thick and commonly stony throughout. The A horizon ranges from 2.5YR to 5YR in hue. The B horizon ranges from 2.5YR to 10R in hue; from 2 to 4 in value; and, when moist, from 2 to 6 in chroma.

This soil is used for pasture, woodland, and wildlife habitat. (Capability classification VIIe, nonirrigated; pasture group 3; woodland group 15)

Hihimanu Series

This series consists of well-drained soils on uplands on the island of Kauai. These soils developed in material weathered from basic igneous rock and colluvium at the base of slopes. They are very steep. Elevations range from 100 to 2,000 feet. The annual rainfall amounts to 70 to 120 inches. The mean annual soil temperature is 69° F. Hihimanu soils are geographically associated with Hanalei and Hanamaulu soils.

These soils are used for water supply, pasture, wildlife habitat, and woodland. The natural vegetation consists of koa, melastoma, yellow foxtail, lantana, false staghornfern, paspalum, hala, guava, ohia, and associated shrubs and grasses.

Hihimanu silty clay loam, 40 to 70 percent slopes (HMMF).—This soil is very steep and occupies uplands. Included in mapping were small areas that are less steep and small areas of stony soils.

In a representative profile the surface layer is dark-brown silty clay loam and silty clay about 15 inches thick. The subsoil, 24 to more than 57 inches thick, is brown, dark-brown, and reddish-brown silty clay and clay that has subangular blocky structure. The substratum is soft, weathered rock. The soil is very strongly acid in the surface layer and subsoil.

Permeability is moderately rapid. Runoff is medium, and the erosion hazard is moderate. In places roots penetrate to a depth of 5 feet or more.

Representative profile: Island of Kauai, lat. 21°56′55.4″ N. and long. 159°27′28.4″ W.

A1—0 to 7 inches, dark-brown (7.5YR 3/3) silty clay loam, dark brown (7.5YR 3/2) when dry; strong, fine and very fine, subangular blocky structure; very hard, firm, sticky and plastic; abundant, coarse, medium and fine roots; a few weathered pebbles; slight effervescence with hydrogen peroxide; very strongly acid; clear, smooth boundary. 7 to 10 inches thick.

A3—7 to 15 inches, dark-brown (7.5YR 3/4), moist and dry, silty clay; weak, fine and very fine, subangular blocky structure; very hard, friable, sticky and plastic; abundant medium, fine, and very fine roots; few coarse roots; many fine pores; few weathered pebbles; upper part mixed with A1 material by worm activity; very strongly acid; gradual, smooth boundary. 6 to 10 inches thick.

B21—15 to 27 inches, reddish-brown (5YR 4/4) silty clay, brown (7.5YR 4/3) when dry; moderate, fine and very fine, subangular blocky structure; very hard, firm, very sticky and plastic; abundant very fine and fine roots, common medium roots, and few large roots; many fine pores; few weathered pebbles; very strongly acid; gradual, smooth boundary. 9 to 15 inches thick.

B22—27 to 45 inches, reddish-brown (5YR 4/4 moist, 5YR 4/3 dry) clay; moderate, fine and very fine, subangular blocky structure; very hard, firm, very sticky and plastic; common very fine and fine roots and few medium roots; many fine pores; few weathered

pebbles; very strongly acid; gradual, smooth boundary. 14 to 20 inches thick.

B23—45 to 72 inches, brown (7.5YR 4/4 moist, 7.5YR 4/3 dry) silty clay; moderate, fine and very fine, subangular blocky structure; very hard, firm, sticky and plastic; few very fine and fine roots; many fine pores; many weathered pebbles; intermittent thin bands of dark brown (7.5YR 3/3) and pockets of reddish brown (5YR 4/4); very strongly acid.

The A horizon ranges from 7.5YR to 10YR in hue, and the B horizon from 5YR to 7.5YR. The depth to soft, weathered rock ranges from 24 to more than 60 inches.

This soil is used for water supply, pasture, wildlife habitat, and woodland. (Capability classification VIIe, nonirrigated; pasture group 8; woodland group 14)

Holomua Series

This series consists of well-drained soils on uplands on the island of Molokai. These soils developed in volcanic ash and material weathered from andesite rock. They are nearly level to strongly sloping. The elevation ranges from 100 to 1,000 feet, but in most places it is less than 500 feet. The annual rainfall amounts to 15 to 20 inches. Most of the rain comes in the form of storms, from November to April. The summers are hot and dry, and there is little or no rain. The mean annual soil temperature is 74° F. Holomua soils are geographically associated with Molokai soils, generally downslope from those soils.

These soils are used for pineapple, pasture, truck crops, and wildlife habitat. The natural vegetation consists of kiawe, uhaloa, ilima, piligrass, and feather fingergrass.

Holomua silt loam, 0 to 3 percent slopes (HvA).—This soil occurs as large, smooth areas. Included in mapping were a few small, slightly eroded and stony areas.

In a representative profile the surface layer is dark reddish-brown silt loam about 9 inches thick. The upper part of the subsoil is dark reddish-brown silt loam, and the lower part is dark reddish-brown and dark-brown silty clay loam that has prismatic structure. The subsoil is 40 to more than 60 inches thick. The substratum is soft, weathered rock. Reaction in the surface layer is neutral in uncultivated areas and very strongly acid in areas used for pineapple. The subsoil is neutral.

Permeability is moderate. Runoff is slow, and the erosion hazard is slight. The available water capacity is about 1.7 inches per foot of soil. In places roots penetrate to a depth of 5 feet or more.

Representative profile: Island of Molokai, lat. 21°08′03″ N. and long. 157°03′01″ W.

Ap1—0 to 2 inches, dark reddish-brown (2.5YR 3/4), moist and dry, silt loam; weak, very fine, granular structure; soft, very friable, slightly sticky and slightly plastic; many roots; violent effervescence with hydrogen peroxide; medium acid; gradual, smooth boundary. 2 to 3 inches thick.

Ap2—2 to 9 inches, dark reddish-brown (2.5YR 3/4) silt loam, dark red (2.5YR 3/6) when dry; weak, medium and coarse, subangular blocky structure breaking to weak, very fine, granular; slightly hard, very friable, slightly sticky and slightly plastic; common roots; many interstitial pores; common, black stains; violent effervescence with hydrogen peroxide; medium acid; clear, wavy boundary. 5 to 8 inches thick.

B21—9 to 20 inches, dark reddish-brown (2.5YR 3/4) silt loam, dark red (2.5YR 3/6) when dry; weak, coarse, prismatic structure breaking to weak, medium and coarse, subangular blocky; slightly hard, very friable, slightly sticky and slightly plastic; common roots; many, very fine, tubular pores and few, fine, tubular pores; violent effervescence with hydrogen peroxide; neutral; gradual, wavy boundary. 6 to 14 inches thick.

B22—20 to 26 inches, dark reddish-brown (2.5YR 3/4), moist and dry, silty clay loam; weak, coarse, prismatic structure breaking to moderate, fine and medium, subangular blocky; hard, friable, sticky and plastic; common roots; many, very fine and fine, tubular pores; violent effervescence with hydrogen peroxide; neutral; clear, smooth boundary. 5 to 6 inches thick.

B23—26 to 38 inches, dark reddish-brown (2.5YR 3/4), moist and dry, silty clay loam; moderate, very fine, subangular blocky structure; hard, friable, sticky and plastic; few roots, most of which are along vertical cleavage planes; many very fine pores; many, very fine, black concretions, initially gritty when rubbed; firm in place; slight effervescence with hydrogen peroxide; few, thin, glazed patches; neutral; gradual, wavy boundary. 11 to 15 inches thick.

IIB24b—38 to 44 inches, dark reddish-brown (5YR 3/4) silty clay loam, yellowish red (5YR 4/6) when dry; strong, very fine, subangular blocky structure; hard, friable, sticky and plastic; few roots; many, very fine, tubular pores; few glazed patches; gritty feeling because of the many hard earthy lumps that break down on rubbing; firm in place; slight effervescence with hydrogen peroxide; neutral; gradual, wavy boundary. 5 to 7 inches thick.

IIB25b—44 to 54 inches, dark-brown (10YR 3/3 and 7.5YR 3/2) silty clay loam, dark brown (7.5YR 4/4) when dry; strong, very fine, subangular blocky structure; hard, friable, sticky and plastic; few roots; many, very fine, tubular pores; few glazed patches; compact in place; initially gritty when rubbed; no effervescence with hydrogen peroxide; neutral; gradual, wavy boundary. 5 to 10 inches thick.

IIB26b—54 to 66 inches, very dark brown (10YR 2/2) silty clay loam, dark grayish brown (10YR 4/2) when dry; moderate and strong, fine and medium, subangular blocky structure; hard, friable, sticky and plastic; few roots, most of which are along cleavage planes; many, very fine and fine, tubular pores; common patchy glaze; firm in place; initially gritty when rubbed; neutral.

The depth to bedrock ranges from 4 to more than 7 feet. In most years the soil is dry in some horizons for more than 90 cumulative days. The A horizon ranges from 2.5YR to 5YR in hue; from 3 to 4 in value when moist; and, in chroma, from 3 to 4 when moist and 4 to 6 when dry. The B horizon ranges from 2.5YR to 5YR in hue, but the buried horizons range from 5YR to 10YR. It ranges from 3 to 4 in value when dry and from 2 to 6 in chroma when moist or dry. The structure ranges from weak to strong in this horizon.

This soil is used for pineapple and truck crops where irrigation water is available and for pasture and wildlife habitat where water is not available. Insufficient water is the principal limiting factor. If irrigated, this soil can be used for a wide variety of climatically suited crops. Wind erosion is a major problem in this area, and adequate windbreaks are needed for crops susceptible to wind damage. (Capability classification I if irrigated, VIc if nonirrigated; pineapple group 1; pasture group 1)

Holomua silt loam, 3 to 7 percent slopes (HvB).—On this soil, runoff is slow and the erosion hazard is slight to moderate.

This soil is used for pineapple, pasture, truck crops, and wildlife habitat. (Capability classification IIe if irrigated, VIc if nonirrigated; pineapple group 2; pasture group 1)

Holomua silt loam, 3 to 7 percent slopes, severely eroded (HvB3).—On this soil, runoff is slow to medium and the erosion hazard is moderate. Most of the surface layer and, in places, part of the subsoil have been removed by wind and water erosion. Vegetation is sparse, especially in summer.

This soil is used for pineapple, pasture, and wildlife habitat. (Capability classification IIIe if irrigated, VIe if nonirrigated; pineapple group 2; pasture group 1)

Holomua silt loam, 7 to 15 percent slopes (HvC).—On this soil, runoff is slow to medium and the erosion hazard is moderate. Slight erosion has occurred in many places. The depth to soft, weathered rock ranges from 2 to 4 feet.

This soil is used for pasture, pineapple, and wildlife habitat. (Capability classification IIIe if irrigated, VIe if nonirrigated; pineapple group 3; pasture group 1)

Holomua silt loam, 7 to 15 percent slopes, severely eroded (HvC3).—This soil occurs along gulches and on slope breaks. It has a profile like that of Holomua silt loam, 0 to 3 percent slopes, except that wind and water erosion have removed most of the surface layer and, in places, part of the subsoil. Runoff is medium, and the erosion hazard is severe. Weathered rock fragments are on the surface in many places. There are a few shallow gullies and many erosion scars. Included in mapping were small, stony areas.

This soil is used for pasture. Vegetation is sparse in most places. (Capability classification IVe if irrigated, VIe if nonirrigated; pineapple group 3; pasture group 1)

Honolua Series

This series consists of well-drained soils on uplands on the island of Maui. These soils developed in material weathered from basic igneous rock. They are moderately sloping to moderately steep. Elevations range from 500 to 1,500 feet. The annual rainfall amounts to 50 to 80 inches. The mean annual soil temperature is 69° F. Honolua soils are geographically associated with Olelo soils.

These soils are used for pineapple, pasture, woodland, wildlife habitat, and water supply. The natural vegetation consists of guava, hilograss, lantana, and ohia.

Honolua silty clay, 7 to 15 percent slopes (HwC).—This soil is on smooth interfluves on uplands. Included in mapping were small areas of Alaeloa and Olelo soils. Also included were small, gently sloping areas and small, eroded spots.

In a representative profile the surface layer is dark-brown silty clay about 12 inches thick. The subsoil, about 58 inches thick, is dark reddish-brown and reddish-brown silty clay that has subangular blocky structure. The substratum is soft, weathered basic igneous rock. The soil is strongly acid in the surface layer and subsoil.

Permeability is moderately rapid. Runoff is slow to medium, and the erosion hazard is slight to moderate. The available water capacity is about 1.2 inches per foot in the surface layer and about 1.4 inches per foot in the subsoil. In places roots penetrate to a depth of 5 feet or more.

Representative profile: Island of Maui, lat. 20°58′58″ N. and long. 156°37′16″ W.

Ap—0 to 12 inches, dark-brown (7.5YR 3/2) silty clay, brown (7.5YR 4/4) when dry; strong, very fine, subangular blocky structure; hard, friable, sticky and plastic; abundant roots; many fine pores; strongly acid; abrupt, wavy boundary. 9 to 14 inches thick.

B21t—12 to 18 inches, dark reddish-brown (5YR 3/4) silty clay, brown (7.5YR 4/4) when dry; strong, very fine, subangular blocky structure; slightly hard, friable, sticky and plastic, and weakly smeary; abundant roots; many fine and medium pores; thick, patchy clay films on peds; many sand-size aggregates that are resistant to crushing; very strongly acid; clear wavy boundary. 4 to 8 inches thick.

B22t—18 to 36 inches, reddish-brown (5YR 4/3) silty clay, reddish brown (5YR 4/4) when dry; strong, very fine, subangular blocky structure; slightly hard, friable, sticky and plastic; plentiful roots; many fine and medium pores; thick, patchy clay films on peds; many sand-size aggregates that are resistant to crushing; few grayish, highly weathered, pebble-size rock fragments; strongly acid; gradual, wavy boundary. 15 to 20 inches thick.

B31—36 to 58 inches, dark reddish-brown (5YR 3/4) silty clay, brown (7.5YR 5/4) when dry; moderate, very fine and fine, subangular blocky structure; slightly hard, friable, sticky and plastic; few roots; many fine pores; thin, patchy clay films on peds; many sand-size aggregates that are resistant to crushing; 20 to 30 percent highly weathered pebble-size rock fragments; strongly acid; clear, wavy boundary. 20 to 26 inches thick.

B32—58 to 70 inches, dark reddish-brown (5YR 3/4) silty clay, brown (7.5YR 5/4) when dry; moderate, very fine and fine, subangular blocky structure; slightly hard, friable, sticky and plastic; few roots; many fine pores; thin, patchy clay films on peds; many sand-size aggregates that are resistant to crushing; 50 to 70 percent highly weathered basic igneous rock; strongly acid.

The solum is more than 40 inches thick. The A horizon ranges from 5YR to 7.5YR in hue, from 3 to 4 in value when dry, and from 2 to 3 in chroma when moist. The structure is moderate to strong. The Bt horizon ranges from 5YR to 7.5YR in hue, from 3 to 4 in value and chroma when moist, and from 3 to 5 in value and from 4 to 8 in chroma when dry. The upper part of the Bt horizon is weakly to moderately smeary.

This soil is used for pineapple, pasture, and woodland. (Capability classification IIIe, nonirrigated; pineapple group 3; pasture group 8; woodland group 7)

Honolua silty clay, 15 to 25 percent slopes (HwD).—On this soil, runoff is medium and the erosion hazard is moderate. Included in mapping were eroded areas on knolls. In these areas, common pebble-size rock fragments are in the surface layer and subsoil.

This soil is used for pineapple, pasture, and water supply. (Capability classification IVe, nonirrigated; pineapple group 3; pasture group 8; woodland group 7)

Honomanu Series

This series consists of well-drained soils on uplands on the island of Maui. These soils developed in volcanic ash. They are gently sloping to moderately steep. Elevations range from 1,000 to 4,500 feet. The annual rainfall amounts to 100 to 250 inches. It is well distributed throughout the year. The mean annual soil temperature is 62° F. Honomanu soils are geographically associated with Amalu, Hana, and Kailua soils.

These soils are used for water supply and wildlife habitat. The natural vegetation consists of koa, kukui. ohia, ricegrass, sedge, and treefern.

Honomanu silty clay, 5 to 25 percent slopes (rHOD).—This soil is on the wettest parts of the northeastern slopes of Haleakala. Included in mapping were small areas of Amalu and Kailua soils and rock outcrops.

In a representative profile the surface layer is very dark brown silt loam and dark yellowish-brown silty clay about 11 inches thick, capped with an organic layer about 3 inches thick. The subsoil, about 26 inches thick, is dark yellowish-brown and brown silty clay that has subangular blocky structure. The substratum is dark yellowish-brown loam and fragmental basic igneous rock. The soil is extremely acid in the surface layer and subsoil.

Permeability is moderately rapid. Runoff is slow, and the erosion hazard is slight. In places roots penetrate to a depth of 4 feet or more.

Representative profile: Island of Maui, lat. 20°48′50″ N. and long. 156°15′14″ W.

O1—3 inches to 0, very dark grayish-brown (10YR 3/2) decaying vegetable matter and some soil material. The soil material is very dark grayish-brown (10YR 3/2) loam; massive; loose, slightly sticky and nonplastic; abundant roots; very porous; extremely acid; clear, wavy boundary. 2 to 5 inches thick.

A11—0 to 3 inches, very dark brown (10YR 2/2) silt loam; massive; very friable, slightly sticky, nonplastic, and strongly smeary; abundant roots; many fine and very fine pores; extremely acid; clear, wavy boundary. 2 to 5 inches thick.

A12—3 to 11 inches, dark yellowish-brown (10YR 3/4) silty clay; moderate, medium, subangular blocky structure; friable, sticky, plastic, and strongly smeary; abundant fine roots; many fine and very fine pores; many dark-brown and black organic stains on ped surfaces; few weathered pebbles; extremely acid; gradual, wavy boundary. 8 to 13 inches thick.

B21—11 to 25 inches, dark yellowish-brown (10YR 4/4) silty clay; moderate, medium, subangular blocky structure; firm, sticky, plastic, and strongly smeary; plentiful fine roots; many fine and medium pores; few black stains on ped surfaces; few weathered pebbles; extremely acid; gradual, smooth boundary. 11 to 16 inches thick.

B22—25 to 37 inches, brown (10YR 4/3) silty clay; moderate, medium, subangular blocky structure; friable, sticky, plastic, and strongly smeary; plentiful fine roots; many fine and medium pores coated with yellowish material that looks like gibbsite; 10 percent weathered cobblestones that have hard cores; extremely acid; clear, smooth boundary. 10 to 13 inches thick.

C—37 to 60 inches, dark yellowish-brown (10YR 3/4) loam; massive; very friable, slightly sticky, nonplastic, and strongly smeary; few fine roots; many fine and medium pores; many fine and very fine (less than 2 millimeters) particles that feel like sand; common small, hard, white fragments that look like gibbsite; 60 to 70 percent slightly weathered rock; extremely acid.

The solum ranges from 31 to 47 inches in thickness. In places a few pebbles, cobblestones, and stones occur on the surface. The organic horizon is lacking in some areas where the vegetation has been removed. The A horizon ranges from 7.5YR to 10YR in hue and from 2 to 3 in value. The B horizon ranges from 5YR to 10YR in hue and from 3 to 4 in value and chroma. The A and B horizons dehydrate irreversibly into black, sharp, angular, very hard, fine, pebble-size aggregates.

This soil is used for water supply and wildlife habitat. (Capability classification IVe, nonirrigated; pasture group 11; woodland group 8)

Honomanu-Amalu association (rHR).—The soils in this association have the profiles described as typical of their respective series. The areas are almost inaccessible by vehicle or on foot. They are on gently sloping to moderately steep, intermediate uplands on East Maui. The Honomanu soils occupy the more sloping, better drained side slopes. The Amalu soils occur on the less sloping tops of ridges and interfluves. The Honomanu soils are well drained; the Amalu soils are poorly drained. Runoff is slow to very slow, and the erosion hazard is slight.

Honomanu soils make up about 60 percent of the association, and Amalu soils about 40 percent. Included in mapping were small areas of Kailua soils and many small, very steep gulches.

This association is used for water supply and wildlife habitat. It is covered with dense rain forest vegetation. (Honomanu part is in capability classification IVe, nonirrigated; woodland group 8. Amalu part is in capability classification VIIw, nonirrigated)

Honouliuli Series

This series consists of well-drained soils on coastal plains on the island of Oahu in the Ewa area. These soils developed in alluvium derived from basic igneous material. They are nearly level and gently sloping. Elevations range from 15 to 125 feet. The annual rainfall amounts to 18 to 30 inches and occurs mainly between November and April. The mean annual soil temperature is 74° F. Honouliuli soils are geographically associated with Ewa, Lualualei, Mamala, and Waialua soils.

These soils are used for sugarcane, truck crops, orchards, and pasture. The natural vegetation consists of kiawe, koa haole, fingergrass, bristly foxtail, and bermudagrass.

Honouliuli clay, 0 to 2 percent slopes (HxA).—This soil occurs in the lowlands along the coastal plains. Included in mapping were small areas of fine-textured alluvial soils that have a stony subsoil. Also included were small areas of shallow, red, friable soils that are underlain by reef limestone.

In a representative profile the soil is dark reddish-brown, very sticky and very plastic clay throughout. The surface layer is about 15 inches thick. The subsoil and substratum have subangular blocky structure, and they have common to many slickensides. The soil is neutral to mildly alkaline.

Permeability is moderately slow. Runoff is slow, and the erosion hazard is no more than slight. The available water capacity is about 1.8 inches per foot of soil. In places roots penetrate to a depth of 5 feet or more. Workability is slightly difficult because of the very sticky and very plastic clay. The shrink-swell potential is high.

Representative profile: Island of Oahu, lat. 21°20′56″ N. and long. 158°12′23″ W.

Ap—0 to 15 inches, dark reddish-brown (5YR 3/2), moist and dry, clay; moderate, medium and fine, granular structure; hard, firm, very sticky and very plastic; plentiful fine roots; common, fine, interstitial pores; few black specks and few shiny specks; few light-colored sand grains; few black concretions that exhibit moderate effervescence with hydrogen peroxide; neutral; clear, smooth boundary. 6 to 16 inches thick.

B2—15 to 26 inches, dark reddish-brown (5YR 3/2) clay, dark reddish brown (5YR 3/3) when dry; moderate, coarse, subangular blocky structure; hard, friable, very sticky and very plastic; plentiful fine roots;

many, fine and medium, tubular pores; common slickensides; few light-colored sand grains; few shiny specks; common black concretions and few black stains that exhibit moderate effervescence with hydrogen peroxide in pores and between peds; neutral; clear, smooth boundary.

C1—26 to 36 inches, dark reddish-brown (5YR 3/2) clay, dark reddish brown (5YR 3/3) when dry; weak, medium and coarse, subangular blocky structure: hard, friable, very sticky and very plastic; plentiful roots; common, fine and medium, tubular pores; few light-colored sand grains; few shiny specks; common black concretions and few black stains in pores and between peds that effervesce with hydrogen peroxide; many moderate slickensides; strong effervescence with hydrogen peroxide; neutral; abrupt, smooth boundary. 8 to 12 inches thick.

C2—36 to 48 inches, dark reddish-brown (5YR 3/2) clay, dark reddish brown (5YR 3/3) when dry; moderate, fine and medium, subangular blocky structure; hard, friable, very sticky and very plastic; abundant fine roots; common, fine and medium, tubular pores; many strong slickensides; few light-colored sand grains; few shiny specks; common black concretions that effervesce with hydrogen peroxide; neutral; gradual, smooth boundary. 10 to 14 inches thick.

C3—48 to 68 inches, dark reddish-brown (5YR 3/2) clay, dark reddish brown (5YR 3/3) when dry; moderate, medium and fine, subangular blocky structure; hard, friable, very sticky and very plastic; few fine roots matted between peds; few, fine, tubular pores; many, strong, deeply grooved slickensides; few light-colored sand grains; few shiny specks; common black concretions that exhibit strong effervescence with hydrogen peroxide; mildly alkaline.

The A horizon ranges from 3 to 4 in value and, in chroma, from 1 to 3 when dry and 2 to 4 when moist. The B horizon ranges from 2 to 3 in chroma when moist. In places gravel occurs in the solum at depths below 3 feet. In some places where these soils adjoin the shallow Mamala soils, coral fragments are mixed in the upper part of the solum by cultivation.

This soil is used for sugarcane, truck crops, and pasture. (Capability classification I if irrigated, IVc if nonirrigated; sugarcane group 4; pasture group 2)

Honouliuli clay, 2 to 6 percent slopes (HxB).—On this soil, runoff is slow and the erosion hazard is slight.

This soil is used for sugarcane, truck crops, and pasture. (Capability classification IIe if irrigated, IVc if nonirrigated; sugarcane group 4; pasture group 2)

Hoolehua Series

This series consists of well-drained soils in depressions and in drainageways on the island of Molokai. These soils developed in old alluvium. The slope is generally 15 percent or less; locally, however, the slope may be as much as 35 percent. Elevations range from 400 to 1,300 feet. The annual rainfall amounts to 20 to 35 inches. Most of the rainfall occurs from November to April; the summers are hot and dry. The mean annual soil temperature is 72° F. Hoolehua soils are geographically associated with Molokai and Lahaina soils.

These soils are used for pineapple, pasture, and wildlife habitat. The natural vegetation consists of lantana, guineagrass, ilima, kiawe, and feather fingergrass.

Hoolehua silty clay, 0 to 3 percent slopes (HzA).—This soil occurs in depressions.

In a representative profile the surface layer is dark reddish-brown silty clay about 15 inches thick. The subsoil is dark reddish-brown silty clay and silty clay loam that has subangular blocky structure. The subsoil is 45 to more than 57 inches thick. The substratum is old alluvium. The reaction ranges from medium acid in areas used for pasture to extremely acid in areas used for pineapple. The subsoil is medium acid to neutral.

Permeability is moderate. Runoff is slow, and the erosion hazard is slight. The available water capacity is about 1.8 inches per foot of soil. In places roots penetrate to a depth of 5 feet or more.

Representative profile: Island of Molokai, lat. 21°09′34″ N. and long. 157°03′08″ W.

Ap1—0 to 9 inches, dark reddish-brown (5YR 3/3) silty clay, dark reddish gray (5YR 4/2) when dry; cloddy, because of tillage; compacted by farm machinery; hard, firm, sticky and plastic; common roots; few, medium and coarse, tubular pores; violent effervescence with hydrogen peroxide; extremely acid; clear, smooth boundary. 8 to 9 inches thick.

Ap2—9 to 15 inches, dark reddish-brown (5YR 3/3), moist and dry, silty clay; cloddy; hard, friable, sticky and plastic; few roots; few, very fine, tubular pores; violent effervescence with hydrogen peroxide; extremely acid; clear, wavy boundary. 4 to 7 inches thick.

B11—15 to 21 inches, dark reddish-brown (5YR 3/3), moist and dry, silty clay loam; weak, fine and medium, subangular blocky structure; slightly hard, very friable, sticky and plastic; few roots; many, very fine and fine, tubular pores and common, medium, tubular pores; many, very fine, black concretions; violent effervescence with hydrogen peroxide; medium acid; clear, wavy boundary. 5 to 9 inches thick.

B12—21 to 27 inches, dark reddish-brown (5YR 3/3), moist and dry, silty clay; weak, fine and medium, subangular blocky structure (slightly stronger than in the B11 horizon); hard, friable, sticky and plastic; no roots; many, very fine and fine, tubular pores and common, medium, tubular pores; many, very fine, black concretions; common black stains in pores; violent effervescence with hydrogen peroxide; slightly acid; clear, wavy boundary. 6 to 7 inches thick.

B21—27 to 49 inches, dark reddish-brown (5YR 3/3 and 5YR 3/4), moist and dry, silty clay; strong, very fine, subangular blocky structure and a few pockets of weak and medium, very fine, subangular blocky structure; very hard, firm, sticky and plastic; no roots; common, very fine, tubular pores; many, very fine, black concretions; common black stains on ped faces; almost continuous coatings on peds; compact in place; common hard earthy lumps, because of aggregate stability, that break down after prolonged rubbing; strong effervescence with hydrogen peroxide; slightly acid; gradual, wavy boundary. 19 to 26 inches thick.

B22—49 to 64 inches, dark reddish-brown (5YR 3/4), moist and dry, silty clay; moderate and strong, fine, subangular blocky structure; very hard, firm, sticky and plastic; no roots; common, very fine, tubular pores; common, very fine, black concretions; few black stains on ped faces; common thin illuviation cutans on ped faces; slightly firm in place; many hard earthy lumps, because of aggregate stability, that break down after prolonged rubbing; moderate effervescence with hydrogen peroxide; slightly acid.

Stratification of the profile ranges from moderate to none. In places there are a few weathered pebbles throughout. There is a significant amount of mica throughout. The A and B horizons range from 5YR to 7.5YR in hue and from 2 to 4 in chroma.

This soil is used principally for pineapple. Small areas are used for truck crops and pasture. (Capability classification I if irrigated, IIIc if nonirrigated; pineapple group 1; pasture group 3).

Hoolehua silty clay, 3 to 7 percent slopes (HzB).—This soil occurs as large areas on uplands. Runoff is slow, and the erosion hazard is slight to moderate.

Included in mapping, along the northern coast of the Hoolehua plains, were about 100 acres of dark-brown windblown material overlying Hoolehua and Lahaina soils. The windblown material is derived from weathered andesite particles that were blown inland from the edge of the northern cliffs. The water intake rate on this included soil is relatively slow and contributes to rapid runoff and a moderate to severe erosion hazard.

This soil is used principally for pineapple; small areas are used for truck crops and pasture. (Capability classification IIe if irrigated, IIIc if nonirrigated; pineapple group 2; pasture group 3)

Hoolehua silty clay, 7 to 15 percent slopes (HzC).—This soil occurs mainly on West Molokai. Runoff is slow to medium, and the erosion hazard is moderate.

This soil is used for pineapple and pasture. (Capability classification IIIe, irrigated or nonirrigated; pineapple group 3; pasture group 3)

Hoolehua silty clay, 15 to 35 percent slopes (HzE).—This soil occurs near Ualapue, Molokai. It is similar to Hoolehua silty clay, 0 to 3 percent slopes, except that the slopes are steep, dominantly 25 to 35 percent. The soil is very sticky and very plastic. Soft, weathered rock occurs at a depth of about 36 inches. The depth to bedrock is 5 feet or more. Runoff is rapid, and the erosion hazard is severe. Workability is difficult. There are few to common stones and boulders.

Included in mapping at the lower elevations were small areas of stony and severely eroded soils. There are a few gullies in these areas.

This soil is used for pasture. (Capability classification VIe, irrigated or nonirrigated; pasture group 3)

Hoolehua silty clay loam, 3 to 10 percent slopes, severely eroded (HyB3).—This soil occurs in the dry, windswept northwestern part of Molokai. The annual rainfall amounts to about 20 inches. Wind has caused much of the erosion, as evidenced by blown-out areas and areas of deposition. Most of the topsoil and, in places, part of the subsoil have been removed; some lag gravel and stones remain on the surface. There are small dunes or hummocks in the most severely eroded areas. Runoff is rapid, and the erosion hazard is severe. Many of the blown-out areas are barren, but other areas are protected by uhaloa, ilima, and fingergrass. Revegetation of bare areas is difficult because of the drying winds and low rainfall. Included in mapping were small areas of severely eroded Molokai soils.

This soil is used for pasture. (Capability classification VIe, irrigated or nonirrigated; pasture group 3)

Hulua Series

This series consists of poorly drained soils on uplands on the island of Kauai. These soils have a layer of indurated ironstone at depths of 10 to 20 inches. They developed in material weathered from basic igneous rock. They are gently sloping to very steep. Elevations range from 400 to 2,400 feet. The annual rainfall amounts to 100 to 200 inches. The mean annual soil temperature is 66° F. Hulua soils are geographically associated with Koolau and Halii soils.

These soils are used for water supply and wildlife habitat. The natural vegetation consists of false staghornfern (uluhe), scrub ohia, clubmoss, uki uki, hilograss, and associated plants.

Hulua gravelly silty clay loam, 25 to 70 percent slopes (HNUF).—This soil is on uplands.

In a representative profile the upper part of the surface layer is black gravelly silty clay loam about 10 inches thick. The subsurface layer, about 6 inches thick, is mottled, dark grayish-brown, massive silty clay. This horizon overlies indurated ironstone, ½ inch to 3 inches thick. The ironstone sheet caps yellowish-red and very dusky red clay loam and soft, weathered rock that extends to a depth of more than 70 inches.

Permeability is moderately rapid, except in the ironstone layer, which is nearly impermeable. Runoff is very rapid, and the erosion hazard is severe to very severe. Roots penetrate to the ironstone.

Representative profile: Island of Kauai, lat. 21°58′16.6″ N. and long. 159°30′21.3″ W.

O1—1 inch to 0, uluhe litter. Undecomposed layer of stems and leaves of uluhe.

A1g—0 to 10 inches, black (5Y 2/1) gravelly silty clay loam, dark gray (2.5Y 4/1) when dry; massive; very hard, firm, slightly sticky and plastic, and weakly smeary; abundant roots; irregularly shaped ironstone pebbles 0.3 to 0.5 inch across; many, small, glistening particles; strongly acid; clear, wavy boundary. 7 to 12 inches thick.

A2—10 to 16 inches, dark grayish-brown (2.5Y 4/2) silty clay, reddish yellow (7.5YR 6/6) with coatings of brown (10YR 4/3) and mottles of white (10YR 8/2) and strong brown (7.5YR 5/8) when dry; massive; hard, firm, sticky and plastic, and weakly smeary; plentiful roots; few very fine pores; strongly acid; abrupt, smooth boundary. 3 to 8 inches thick.

B2ir—16 to 18 inches, very dark brown (7.5R 2/2 and 2/4) and brown (7.5YR 4/4) indurated ironstone sheet; some fine pores contain a whitish, soft material; ironstone sheet is laminated and has a troweled upper surface; clear, wavy boundary. ½ inch to 3 inches thick.

C1—18 to 30 inches, yellowish-red (5YR 5/6) clay loam, reddish yellow (7.5YR 6/6) when dry; has appearance of original rock structure but has pores coated with material of strong brown (7.5YR 5/6), red (2.5YR 4/8), and yellowish red (5YR 5/8); fracture faces have coatings of reddish black (10R 2/1), dark red (10R 3/6), and black (N 2/0) when moist; hard, firm, sticky and plastic, and smeary; no roots; many fine pores; this layer consists of hard and soft material; hard material can be broken down with difficulty when moist; very strongly acid; gradual, smooth boundary. 11 to 14 inches thick.

C2—30 to 60 inches, very dusky red (2.5YR 2/2) clay loam; many fine mottles of reddish yellow (7.5YR 7/6), dark red (2.5YR 3/6), and yellowish red (5YR 5/6); weak red (2.5YR 4/2) with mottles of red (2.5YR 5/6) and reddish yellow (7.5YR 7/6) when dry; hard, firm, sticky and plastic; no roots; common medium and fine pores; has appearance of the original rock structure, but pores are filled with illuvial material; very strongly acid.

The A1g horizon ranges from 2.5Y to 5Y in hue and from 2 to 3 in value. The ironstone sheet ranges from ½ inch to 3 inches in thickness. The C horizon ranges from 10R to 7.5YR in hue, from 2 to 5 in value, and from 2 to 8 in chroma. The depth to ironstone ranges from 10 to 20 inches.

This soil is used for water supply and wildlife habitat. (Capability classification VIIe, nonirrigated; woodland group 16)

Hulua gravelly silty clay loam, 3 to 25 percent slopes (HNUD).—This soil is similar to Hulua gravelly silty clay loam, 25 to 70 percent slopes, except that it is gently sloping to moderately steep. Runoff is rapid, and the erosion hazard is severe.

This soil is used for water supply and wildlife habitat. (Capability classification VIe, nonirrigated; woodland group 16)

Hydrandepts-Tropaquods Association

Areas mapped as Hydrandepts-Tropaquods association (rHT) consist of well-drained to poorly drained soils on uplands. These soils are on the northern slopes of West Maui and the northern and eastern slopes of East Maui. They developed in volcanic ash and in material weathered from cinders and basic igneous rock. They are moderately sloping to steep. Elevations range from 1,000 to 6,000 feet. The annual rainfall amounts to 100 to 350 inches. The mean annual soil temperature is 60° F. This association is geographically associated with soils of the Amalu, Honomanu, and Olelo series.

Hydrandepts make up about 60 percent of the association, and Tropaquods 40 percent. Included in mapping were small areas of Rough mountainous land. Also included were small peat bogs.

Hydrandepts are the steeper areas of the association. These are well drained to moderately well drained soils that are similar to those of the Honomanu series. The surface layer is high in organic-matter content. The subsoil is dark-brown or dark yellowish-brown, smeary silty clay loam or silty clay. The substratum consists of volcanic ash and cinders or weathered basic igneous rock. These soils dehydrate irreversibly into fine pebble-size aggregates.

Tropaquods are poorly drained soils that are similar to those of the Amalu and Olokui series. They have a peaty or mucky surface layer that overlies a dark gray to very dark gray, mottled layer. The mottled layer rests on an ironstone sheet 1/4 to 1 inch thick. The ironstone is at a depth of 10 to 20 inches. It normally caps highly weathered basic igneous rock.

The soils in this association have low bearing capacity and low shear strength. They are slippery and difficult to traverse. Because of their ability to absorb water and to transmit it rapidly, these soils are important for maintenance of ground water for domestic use and irrigation.

This association is used for water supply and wildlife habitat. The natural vegetation consists of ohia, puakeawe, sedges, false staghornfern, treefern, and other rain forest vegetation. (Hydrandepts soils are in capability classification VIIe, nonirrigated. Tropaquods soils are in capability classification VIIw, nonirrigated)

Iao Series

This series consists of well-drained soils on valley fill and alluvial fans. These soils developed in alluvium derived from basic igneous rock. They are nearly level to moderately sloping. Elevations range from 100 to 500 feet. The annual rainfall amounts to 25 to 40 inches. The mean annual soil temperature is 74° F. Iao soils are geographically associated with Paia, Pulehu, and Wailuku soils.

These soils are used for sugarcane. Small acreages are used for pasture and homesites. The natural vegetation consists of bermudagrass, feather fingergrass, koa haole, lantana, and Natal redtop.

Iao clay, 3 to 7 percent slopes (IcB).—This soil is on smooth alluvial fans and valley fill. Included in mapping were small areas of Paia and Wailuku soils. Also included were small, nearly level areas.

In a representative profile the surface layer is dark-brown clay about 15 inches thick. The subsoil, about 45 inches thick, is very dark brown, dark-brown, and very dark grayish-brown clay and silty clay. The substratum is clayey alluvium. The soil is neutral in the surface layer and subsoil.

Permeability is moderately slow. Runoff is medium, and the erosion hazard is slight to moderate. The available water capacity is about 1.7 inches per foot in the surface layer and subsoil. In places roots penetrate to a depth of 5 feet or more.

Representative profile: Island of Maui, lat. 20°54′14″ N. and long. 156°30′22″ W.

Ap—0 to 15 inches, dark-brown (10YR 3/3) clay, dark gray (10YR 4/1) when dry; massive; very hard, firm, very sticky and very plastic; abundant roots; many fine pores; few cracks up to 1/4 inch wide; many weathered basalt sand grains; strong effervescence with hydrogen peroxide; neutral; gradual, smooth boundary. 12 to 18 inches thick.

B21—15 to 25 inches, very dark brown (10YR 2/2) clay, very dark grayish brown (10YR 3/2) when rubbed, dark brown (10YR 3/3) when dry; weak, medium and coarse, subangular blocky structure; very hard, firm, very sticky and very plastic; abundant roots; many very fine pores; firm in place; many weathered basalt sand grains; few basalt pebbles; strong effervescence with hydrogen peroxide; neutral; gradual, smooth boundary. 8 to 14 inches thick.

B22—25 to 48 inches, dark-brown (10YR 3/3), moist and dry, clay; moderate, medium and coarse, subangular blocky structure; very hard, firm, very sticky and very plastic; few fine roots; many fine pores; continuous pressure cutans on peds; compact in place; many weathered basalt sand grains and pebbles; strong effervescence with hydrogen peroxide; neutral; gradual, smooth boundary. 20 to 27 inches thick.

B3—48 to 60 inches, very dark grayish-brown (10YR 3/2) silty clay, dark brown (10YR 3/3) when dry; massive; hard, firm, sticky and plastic; few roots; many fine and medium pores; many weathered basalt sand grains and pebbles; strong effervescence with hydrogen peroxide; neutral.

The solum is more than 40 inches thick. A few cobblestones occur on the surface in some places. The A horizon ranges from 2 to 3 in value when moist and 3 to 4 when dry, and, in chroma, from 1 to 3 when moist and 1 to 2 when dry. The B horizon ranges from 3 to 4 in value when dry, and, in chroma, from 2 to 3 when moist or dry. The texture ranges from silty clay to clay.

This soil is used for sugarcane and homesites. (Capability classification IIe if irrigated, IIIc if nonirrigated; sugarcane group 1; pasture group 3)

Iao clay, 7 to 15 percent slopes (IcC).—On this soil, runoff is medium and the erosion hazard is moderate.

This soil is used for sugarcane and homesites. (Capability classification IIIe, irrigated or nonirrigated; sugarcane group 1; pasture group 3)

Iao silty clay, 0 to 3 percent slopes (IaA).—On this soil, runoff is slow and the erosion hazard is no more than slight.

This soil is used for sugarcane. (Capability classification I if irrigated, IIIc if nonirrigated; sugarcane group 1; pasture group 3)

Iao silty clay, 3 to 7 percent slopes (IaB).—This soil has a profile like that of Iao clay, 3 to 7 percent slopes, except for the texture of the surface layer.

This soil is used for sugarcane. (Capability classification IIe if irrigated, IIIc if nonirrigated; sugarcane group 1; pasture group 3)

Iao cobbly silty clay, 3 to 7 percent slopes (IbB).—This soil has a profile like that of Iao clay, 3 to 7 percent slopes, except for the texture of the surface layer and the content of cobblestones.

This soil is used for sugarcane and homesites. (Capability classification IIe if irrigated, IIIs if nonirrigated; sugarcane group 1; pasture group 3)

Iao cobbly silty clay, 7 to 15 percent slopes (IbC).—On this soil, runoff is medium and the erosion hazard is moderate.

This soil is used for sugarcane and pasture. (Capability classification IIIe, irrigated or nonirrigated; sugarcane group 1; pasture group 3)

Io Series

This series consists of well-drained soils on uplands on the island of Maui. These soils developed in volcanic ash and material weathered from cinders. They are moderately sloping to moderately steep. Elevations range from 1,000 to 2,500 feet. The annual rainfall amounts to 25 to 35 inches. The mean annual soil temperature is 69° F. Io soils are geographically associated with Kula, Oanapuka, and Ulupalakua soils.

These soils are used for pasture and wildlife habitat. Small areas are used for truck crops. The natural vegetation consists of bermudagrass, buffelgrass, burclover, guineagrass, lantana, and Natal redtop.

Io silt loam, 7 to 25 percent slopes (ISD).—This soil is on smooth, low mountain slopes. Included in mapping were small areas of Kula and Oanapuka soils. Also included were small, cobbly areas and small, steep areas near cinder cones.

In a representative profile the surface layer is very dark brown silt loam about 10 inches thick. The subsurface layer is dark-brown silty clay loam about 7 inches thick. The subsoil, 10 to 30 inches thick, is dark-brown and dark reddish-brown clay loam that has subangular blocky structure. The substratum is black, unweathered, fine cinders and dark reddish-brown loam. The soil is neutral in the surface layer and mildly alkaline in the subsoil.

Permeability is moderately rapid. Runoff is slow to medium, and the erosion hazard is slight to moderate. The available water capacity is about 1.8 inches per foot in the surface layer and subsoil. In places roots penetrate to a depth of more than 25 inches.

Representative profile: Island of Maui, lat. 20°39′20″ N. and long. 156°24′40″ W.

Ap—0 to 10 inches, very dark brown (10YR 2/2) silt loam, dark grayish brown (10YR 4/2) when dry; weak and moderate, fine and very fine, granular structure; slightly hard, very friable, slightly sticky and slightly plastic; abundant fine roots; many fine and very fine pores; slight effervescence with hydrogen peroxide; neutral; clear, wavy boundary. 9 to 12 inches thick.

A1—10 to 17 inches, dark-brown (7.5YR 3/2) silty clay loam, brown (7.5YR 4/2) when dry; weak and moderate, fine, subangular blocky structure; hard, friable, sticky and plastic; abundant fine roots; many fine and very fine pores; mildly alkaline; gradual, wavy boundary. 4 to 9 inches thick.

B21—17 to 25 inches, dark-brown (10YR 3/3) clay loam, brown (10YR 4/3) when dry; weak, fine and medium, subangular blocky structure; hard, friable, sticky and plastic; abundant fine roots; many fine pores; thin, dark coatings that look like organic stains on peds; compact in place; mildly alkaline; clear, smooth boundary. 7 to 11 inches thick.

B22—25 to 30 inches, dark reddish-brown (5YR 3/3) and yellowish-red (5YR 4/6) clay loam, reddish brown (5YR 4/4) and yellowish red (5YR 5/6) when dry; weak and moderate, fine, subangular blocky structure; hard, friable, sticky and plastic; abundant fine roots; many medium and fine pores; 20 percent fine cinders; mildly alkaline; abrupt, smooth boundary. 4 to 6 inches thick.

IIC1—30 to 39 inches, black cinders 1 to 10 millimeters in size; single grain; extremely hard and loose; few fine roots; moderately alkaline; abrupt, smooth boundary. 8 to 10 inches thick.

IIIC2—39 to 45 inches, dark reddish-brown (5YR 3/4) loam, reddish yellow (7.5YR 6/6) when dry; massive; slightly hard, friable, slightly sticky and slightly plastic, and weakly smeary; few fine roots; many fine pores; moderately alkaline.

The depth to black, unweathered cinders ranges from 24 to 38 inches. A few cobblestones and stones occur on the surface in some areas. The A horizon ranges from 7.5YR to 10YR in hue and, in value, from 2 to 3 when moist and 3 to 4 when dry. The texture is silt loam and silty clay loam. The B horizon ranges from 5YR to 10YR in hue. It ranges in value from 2 to 3 when moist and 3 to 4 when dry and, in chroma, from 2 to 3 when moist and 3 to 6 when dry. The texture is clay loam or silty clay loam.

This soil is used for pasture, truck crops, and wildlife habitat. (Capability classification IVe, nonirrigated; pasture group 4; woodland group 2)

Ioleau Series

This series consists of well-drained soils on uplands on the island of Kauai. These soils developed in material weathered from basic igneous rock, probably mixed with volcanic ash. They are gently sloping to steep. Elevations range from 100 to 750 feet. The annual rainfall amounts to 40 to 70 inches. The mean annual soil temperature is 72° F. Ioleau soils are geographically associated with Lihue and Puhi soils.

These soils are used for irrigated sugarcane, pasture, pineapple, irrigated orchards, irrigated truck crops, wildlife habitat, and woodland. The natural vegetation consists of lantana, koa haole, guava, and associated shrubs and grasses.

Ioleau silty clay loam, 6 to 12 percent slopes (IoC).—This soil is on ridgetops in the uplands.

In a representative profile the surface layer is dark-brown and yellowish-red silty clay loam 15 inches thick. The subsoil, 40 to 60 inches thick, is dark-brown and dark reddish-brown silty clay that has subangular blocky structure and is very compact in place. The substratum is soft, weathered rock. The soil is very strongly acid to extremely acid throughout.

Permeability is slow to moderately slow. Runoff is medium, and the erosion hazard is moderate. The available water capacity is about 1.4 inches per foot of soil. Roots penetrate to a depth of 15 to 25 inches or to the plow depth.

Representative profile: Island of Kauai, lat. 22°07′32.9″ N. and long. 157°13′03″ W.

Ap1—0 to 6 inches, dark-brown (7.5YR 3/4) silty clay loam, brown (7.5YR 4/4) when dry; cloddy, breaking to moderate, fine and very fine, subangular blocky structure; hard, firm, sticky and plastic; abundant medium and fine roots and plentiful very fine roots; very strongly acid; abrupt, wavy boundary. 6 to 8 inches thick.

Ap2—6 to 15 inches, mixture of yellowish-red (5YR 4/6) silty clay loam, strong brown (7.5YR 5/6) when dry; massive; slightly hard, friable, sticky and plastic; and yellowish-red (5YR 4/6) silty clay, reddish brown (5YR 4/4) when dry; strong, very fine, subangular blocky structure; hard, firm, sticky and plastic; few medium roots and plentiful fine and very fine roots; common fine pores; very strongly acid; abrupt, wavy boundary. 7 to 10 inches thick.

B21t—15 to 27 inches, dark reddish-brown (5YR 3/4) silty clay, reddish brown (5YR 4/4) when dry; strong, fine and very fine, subangular blocky structure; very hard, firm, sticky and plastic; very few fine and very fine roots; common very fine pores; very compact in place; many moderately thick clay films on ped faces; very strongly acid; clear, wavy boundary. 5 to 12 inches thick.

B22t—27 to 38 inches, dark-brown (7.5YR 3/2) silty clay, yellowish red (5YR 3/6) in pores, dark brown (7.5YR 4/4) when dry; strong, fine and very fine, subangular blocky structure; very hard, firm, sticky and plastic; very few fine and very fine roots; few medium pores and many very fine pores; compact in place; many moderately thick clay films on ped faces and in pores; few pebbles; very strongly acid; clear, wavy boundary. 9 to 11 inches thick.

B23t—38 to 57 inches, dark-brown (7.5YR 3/3) light silty clay, dark brown (7.5YR 4/4) in pores, dark brown (7.5YR 4/4) when dry; strong, fine and very fine, subangular blocky structure; slightly hard, firm, slightly sticky and slightly plastic; few medium, fine, and very fine roots; many very fine pores; patchy, moderately thick clay films on ped faces; continuous in pores; few pebbles; extremely acid; clear, wavy boundary. 15 to 22 inches thick.

B24t—57 to 61 inches, dark reddish-brown (5YR 3/4) silty clay loam, reddish brown (5YR 4/4) when dry; moderate, fine and very fine, subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; no roots; many very fine pores; patchy, moderately thick clay films on ped faces; continuous in pores; extremely acid.

The A horizon ranges from 5YR to 10YR in hue. In places the texture of the A horizon is clay loam. The B horizon ranges from 2.5YR to 7.5YR in hue, from 3 to 4 in value, and from 2 to 6 in chroma. The depth to the very compact B21t ranges from 15 to 25 inches.

This soil is used for sugarcane, pasture, pineapple, orchards, and truck crops. (Capability classification IIIe, irrigated or nonirrigated; sugarcane group 1; pineapple group 6; pasture group 6; woodland group 6)

Ioleau silty clay loam, 2 to 6 percent slopes (IoB).—This soil has a profile like that of Ioleau silty clay loam, 6 to 12 percent slopes, except that it is 10 to 20 inches deeper to the compact layer. Runoff is slow, and the erosion hazard is slight. Roots penetrate to a depth of 25 to 40 inches.

This soil is used for sugarcane, pasture, pineapple, orchards, and truck crops. (Capability classification IIe, irrigated or nonirrigated; sugarcane group 1; pineapple group 5; pasture group 6; woodland group 6)

Ioleau silty clay loam, 12 to 20 percent slopes, eroded (IoD2).—This soil is similar to Ioleau silty clay loam, 6 to 12 percent slopes, except that it is moderately steep and part of the surface layer has been removed by erosion. Runoff is rapid, and the erosion hazard is moderate to severe.

This soil is used for sugarcane, pineapple, and pasture. (Capability classification IVe, irrigated or nonirrigated; sugarcane group 1; pineapple group 6; pasture group 6; woodland group 6)

Ioleau silty clay loam, 20 to 35 percent slopes, eroded (IoE2).—This soil is similar to Ioleau silty clay loam, 6 to 12 percent slopes, except that it is steep and most of the surface layer has been removed by erosion. Runoff is rapid, and the erosion hazard is severe.

This soil is used for pasture, woodland, sugarcane, pineapple, and water supply. (Capability classification VIe, nonirrigated; pasture group 6; woodland group 6)

Jaucas Series

This series consists of excessively drained, calcareous soils that occur as narrow strips on coastal plains, adjacent to the ocean. These soils occur on all the islands of this survey area. They developed in wind- and water-deposited sand from coral and seashells. They are nearly level to strongly sloping. Elevations range from sea level to 100 feet; but locally on West Molokai, the elevation is as high as 650 feet. The annual rainfall amounts to 10 to 40 inches. The mean annual soil temperature is 75° F. Jaucas soils are geographically associated with Pulehu, Mokuleia, Kaloko, and Lualualei soils.

In this survey area a dark variant of the Jaucas series was mapped. This soil, Jaucas loamy fine sand, dark variant, 0 to 8 percent slopes, is described in alphabetical order, along with other mapping units of this series.

These soils are used for pasture, sugarcane, truck crops, alfalfa, recreational areas, wildlife habitat, and urban development. The natural vegetation consists of kiawe, koa haole, bristly foxtail, bermudagrass, fingergrass, and Australian saltbush.

Jaucas sand, 0 to 15 percent slopes (JcC).—The slope range of this soil is 0 to 15 percent, but in most places the slope does not exceed 7 percent. Included in mapping were narrow strips of Beaches and areas of Pulehu, Mokuleia, and Keaau soils.

In a representative profile the soil is single grain, pale brown to very pale brown, sandy, and more than 60 inches deep. In many places the surface layer is dark brown as a result of accumulation of organic matter and alluvium. The soil is neutral to moderately alkaline throughout the profile.

Permeability is rapid, and runoff is very slow to slow. The hazard of water erosion is slight, but wind erosion is a severe hazard where vegetation has been removed. The available water capacity is 0.5 to 1.0 inch per foot of soil. In places roots penetrate to a depth of 5 feet or more. Workability is slightly difficult because the soil is loose and lacks stability for use of equipment.

Representative profile: Island of Molokai, lat. 21°05′38″ N. and long. 157°13′03″ W.

C1 0 to 13 inches, pale-brown (10YR 6/3) sand, light yellowish brown (10YR 6/4) when dry; single grain; loose, nonsticky and nonplastic; plentiful roots; violent effervescence with dilute hydrochloric acid; neutral; gradual, wavy boundary. 3 to 15 inches thick.

C2—13 to 22 inches, light yellowish-brown (10YR 6/4) sand, very pale brown (10YR 7/4) when dry; single grain; loose, nonsticky and nonplastic; few roots; violent effervescence with dilute hydrochloric acid; mildly alkaline; gradual, wavy boundary. 6 to 30 inches thick.

C3—22 to 60 inches, very pale brown (10YR 7/4) sand; single grain; loose, nonsticky and nonplastic; violent effervescence with dilute hydrochloric acid; neutral.

The texture of the surface layer is dominantly sand, but in a few places it is fine sand or loamy sand. In some places there is an A horizon, a few inches thick, that is darkened by organic matter and alluvium. The profile is 10YR in hue. It ranges from 6 to 7 in value, and, in chroma, from 2 to 4 when moist. Pebble-size fragments of coral and seashell are common in the profile.

This soil is used for pasture, sugarcane, truck crops, and urban development. (Capability classification IVs if irrigated, VIe if nonirrigated; sugarcane group 1; pasture group 1)

Jaucas sand, saline, 0 to 12 percent slopes (JcC).—This soil occurs near the ocean in areas where the water table is near the surface and salts have accumulated. It is somewhat poorly drained in depressions but excessively drained on knolls. In the depressions there is normally a layer of silty alluvial material flocculated by the high concentration of soluble salts. The water table is normally within a depth of 30 inches.

This soil is used for pasture, wildlife habitat, and urban development. Vegetation on the salty soil in the depressions consists of salt-tolerant plants. Kiawe grows profusely on the better drained soils on knolls. (Capability classification VIIs, nonirrigated; pasture group 1)

Jaucas loamy fine sand, 0 to 8 percent slopes (JfB).—This soil occurs on old beaches and on windblown sand deposits in the western and southern parts of Kauai. It has a profile like that of Jaucas sand, 0 to 15 percent slopes, except for the texture of the surface layer.

This soil is used for pasture, recreational areas, wildlife habitat, sugarcane, and alfalfa. (Capability classification IVs if irrigated, VIe if nonirrigated; sugarcane group 1; pasture group 1)

Jaucas loamy fine sand, dark variant, 0 to 8 percent slopes (JkB).—This soil occurs on Kauai near the town of Waimea. Unlike other soils of the Jaucas series, sand and coral sand are mixed throughout the profile. The basaltic sand gives this soil a dark-brown to black color.

This soil is used for sugarcane, pasture, and homesites. (Capability classification IVs if irrigated, VIe if nonirrigated; sugarcane group 1; pasture group 1)

Jaucas-Blown-out land complex (JL).—This complex occurs as a long, nearly level to moderately sloping strip in the northwestern part of the island of Molokai. It is inland where strong prevailing winds have lifted and carried coral sand from sea level to elevations of about 650 feet. The Jaucas soil, which makes up 25 to 70 percent of the acreage, occurs as small dunes. In many places it is mixed with fine material from Blown-out land, and the texture is loamy sand. Blown-out land consists of an exposed compact subsoil and substratum similar to those of Molokai soils. Included in mapping were a few limestone outcrops.

This complex is used for pasture. Kiawe trees are scrubby and scattered because they cannot obtain moisture from the water table. Most of the forage consists of grasses that grow mainly during the rainy season. Much of the area is barren. Strong winds are prevalent, and wind and water erosion is active. (Capability classification VIe, nonirrigated; pasture group 1)

Kaena Series

This series consists of very deep, poorly drained soils on alluvial fans and talus slopes on the islands of Oahu and Kauai. These soils developed in alluvium and colluvium from basic igneous material. They are gently sloping to steep and are commonly stony. Elevations range from 50 to 150 feet. The annual rainfall amounts to 30 to 45 inches, most of which occurs between November and April. The mean annual soil temperature is 74° F. Kaena soils are geographically associated with Honouliuli, Lualualei, and Waialua soils.

In this survey area brown variants of the Kaena series were mapped. These soils, Kaena clay, brown variant, 1 to 6 percent slopes, and Kaena clay, brown variant, 6 to 12 percent slopes, are described in alphabetical order, along with other mapping units of the series.

These soils are used for sugarcane, truck crops, pasture, and homesites. The natural vegetation consists of kiawe, klu, lantana, koa haole, and fingergrass.

Kaena stony clay, 6 to 12 percent slopes (KaeC).—This soil occurs on alluvial fans. Included in mapping were small areas of clayey, dark reddish-brown soils that are moderately well drained to well drained.

In a representative profile the surface layer is very dark gray clay about 10 inches thick. The next layer, 36 to more than 48 inches thick, is dark-gray and dark grayish-brown clay that has prismatic structure. It is underlain by highly weathered gravel. The soil is very sticky and very plastic, and it is mottled. It is slightly acid to neutral.

Permeability is slow. Runoff is slow to medium, and the erosion hazard is slight to moderate. The available water capacity is about 1.4 inches per foot in the surface layer and about 1.7 inches per foot in the subsoil. Workability is difficult because of the narrow range of moisture content within which the soils can be cultivated. There are sufficient stones to hinder, but not prevent, cultivation. The shrink-swell potential is very high. In places the soil is affected by seepage.

Representative profile: Island of Oahu, lat. 21°41′50″ N. and long. 157°59′08″ W.

Ap—0 to 10 inches, very dark gray (10YR 3/1), moist and dry, stony clay; strong, fine and medium, subangular blocky structure; extremely hard, very firm, very sticky and very plastic; abundant fine and medium roots; common, very fine, tubular and interstitial pores; few coral fragments; angular stones; few highly weathered pebble-size basalt fragments; common, black, organic stains; common, fine, distinct, dark yellowish-brown mottles; slight effervescence with hydrogen peroxide; slight effervescence with hydrochloric acid; neutral; abrupt, smooth boundary. 8 to 12 inches thick.

ACg—10 to 37 inches, dark-gray (10YR 4/1), moist and dry, stony clay; weak, coarse, prismatic structure; extremely hard, very firm, very sticky and very plastic; plentiful very fine and fine and few medium roots; many, very fine, tubular pores; many prominent slickensides; many, fine, distinct, dark reddish-brown mottles; few highly weathered, pebble-size rock fragments; few black stains; slight effervescence with hydrogen peroxide; neutral; gradual, wavy boundary. 20 to 30 inches thick.

C1g—37 to 45 inches, dark grayish-brown (10YR 4/2), moist and dry, stony clay; weak, coarse, prismatic structure; extremely hard, very firm, very sticky and very plastic; few very fine roots; common, very fine, tubular pores; many distinct slickensides; common, fine, distinct, strong-brown mottles; few highly weathered, pebble-size rock fragments; few black stains; common, strong-brown, very fine specks; few fine and medium gypsum crystals; slight effervescence with hydrogen peroxide; neutral; clear, smooth boundary. 7 to 9 inches thick.

C2—45 to 54 inches, dark grayish-brown (10YR 4/2), moist and dry, stony clay; common, fine, distinct, strong-brown mottles; massive; extremely hard; very fine roots; common, very fine, tubular pores; common moderately strong slickensides; many highly weathered pebbles and basaltic stones; neutral.

The amount of stones in the profile ranges from less than 10 percent in the upper part to about 40 percent in the lower part. The number increases with depth. The A horizon ranges from 10YR to 7.5YR in hue and from 2 to 3 in value when moist and 3 to 4 when dry. The C horizon ranges from 10YR to 7.5YR in hue, from 3 to 4 in value, and from 1 to 2 in chroma when moist or dry. Mottles in the C horizon range from distinct to prominent.

This soil is used for sugarcane and pasture. (Capability classification IIIw if irrigated, IVw if nonirrigated; sugarcane group 4; pasture group 7; woodland group 4)

Kaena stony clay, 2 to 6 percent slopes (KaeB).—On this soil, runoff is slow and the erosion hazard is slight.

This soil is used for sugarcane, pasture, and homesites. (Capability classification IIIw if irrigated, IVw if nonirrigated; sugarcane group 4; pasture group 7; woodland group 4)

Kaena stony clay, 12 to 20 percent slopes (KaeD).—On this soil, runoff is medium and the erosion hazard is moderate.

This soil is used for sugarcane, pasture, and homesites. (Capability classification IVw if irrigated, VIw if nonirrigated; sugarcane group 4; pasture group 7; woodland group 4)

Kaena very stony clay, 10 to 35 percent slopes (KanE).—This soil occurs on talus slopes and alluvial fans. It has a profile like that of Kaena stony clay, 6 to 12 percent slopes, except that there are many stones on the surface and in the profile. Runoff is medium to rapid, and the erosion hazard is moderate to severe. Workability is difficult because the soil is stony, steep, and very sticky and very plastic. Included in mapping were small areas of Rock outcrop, Stony steep land, and small areas where the slope is less than 10 percent.

This soil is used for pasture and urban development. (Capability classification VIs, nonirrigated; pasture group 7; woodland group 4)

Kaena clay, 2 to 6 percent slopes (KaB).—This soil has a profile like that of Kaena stony clay, 6 to 12 percent slopes, except that there are few or no stones in the surface layer. Runoff is slow, and the erosion hazard is slight.

This soil is used for sugarcane, truck crops, pasture, and urban development. (Capability classification IIIw if irrigated, IVw if nonirrigated; sugarcane group 4; pasture group 7; woodland group 4)

Kaena clay, 6 to 12 percent slopes (KaC).—This soil has a profile like that of Kaena stony clay, 6 to 12 percent slopes, except that there are few or no stones in the surface layer. Included in mapping were small stony areas at the higher elevations.

This soil is used for sugarcane and pasture. (Capability classification IIIw if irrigated, IVw if nonirrigated; sugarcane group 4; pasture group 7; woodland group 4)

Kaena clay, brown variant, 1 to 6 percent slopes (KavB).—This soil occurs on alluvial fans on Kauai. It is geographically associated with Kalapa soils.

This variant is somewhat poorly drained, and the surface layer is browner than is typical of the Kaena series. Also, it occurs at elevations up to 500 feet, and the rainfall amounts to 50 to 75 inches per year.

Permeability is slow to moderately slow. Runoff is slow, and the erosion hazard is slight. The available water capacity is about 1.5 inches per foot of soil. In places roots penetrate to a depth of 5 feet or more. Workability is difficult.

This soil is used for sugarcane and pasture. (Capability classification IIIw if irrigated, IVw if nonirrigated; sugarcane group 3; pasture group 7; woodland group 4)

Kaena clay, brown variant, 6 to 12 percent slopes (KavC).—This soil occurs on Kauai. It is geographically associated with Kalapa soils. It is similar to Kaena clay, brown variant, 1 to 6 percent slopes, except for the slope. Runoff is medium, and the erosion hazard is slight to moderate.

This soil is used for sugarcane and pasture. (Capability classification IIIw if irrigated, IVw if nonirrigated; sugarcane group 3; pasture group 7; woodland group 4)

Kahana Series

This series consists of well-drained soils on uplands on the island of Maui. These soils developed in material weathered from basic igneous rock. They are gently sloping to moderately steep. Elevations range from 100 to 1,200 feet. The annual rainfall amounts to 30 to 45 inches. The mean annual soil temperature is 70° F. Kahana soils are geographically associated with Alaeloa, Honolua, and Lahaina soils.

These soils are used for sugarcane, pineapple, and homesites. The natural vegetation consists of guava, klu, koa haole, lantana, Natal redtop, and yellow foxtail.

Kahana silty clay, 7 to 15 percent slopes (KbC).—This soil is on smooth uplands. Included in mapping were small areas of Alaeloa and Lahaina soils.

In a representative profile the surface layer is dark reddish-brown silty clay about 14 inches thick. The subsoil is dark reddish-brown silty clay, about 50 inches thick, that has subangular blocky structure. The substratum is soft, weathered, basic igneous rock. These soils are strongly acid and very strongly acid in the surface layer, strongly acid in the upper part of the subsoil, and neutral in the lower part.

Permeability is moderately rapid. Runoff is slow to medium, and the erosion hazard is slight to moderate. The available water capacity is about 1.3 inches per foot

in the surface layer and 1.4 inches per foot in the subsoil. In places roots penetrate to a depth of 5 feet or more.

Representative profile: Island of Maui, lat. 20°57′44″ N. and long. 156°39′00″ W.

Ap1—0 to 7 inches, dark reddish-brown (2.5YR 2/4) silty clay, dark reddish brown (2.5YR 3/4) when dry; moderate, fine and very fine, subangular blocky structure; hard, friable, very sticky and very plastic; abundant fine roots; many fine and very fine pores; many, very fine, black concretions; violent effervescence with hydrogen peroxide; strongly acid; clear, wavy boundary. 6 to 9 inches thick.

Ap2—7 to 14 inches, dark reddish-brown (2.5YR 2/4) silty clay, dark reddish brown (2.5YR 3/4) when dry; moderate, medium and fine, subangular blocky structure; hard, firm, very sticky and very plastic; abundant fine roots; many fine and very fine pores; many, fine and very fine, black concretions; violent effervescence with hydrogen peroxide; very strongly acid; abrupt, wavy boundary. 6 to 9 inches thick.

B1—14 to 22 inches, dark reddish-brown (2.5YR 3/4) silty clay, dark red (2.5YR 3/6) when dry; strong, fine and very fine, subangular blocky structure; hard, firm, sticky and very plastic; plentiful fine roots; many, fine and very fine, tubular pores; many, fine and very fine, black concretions; few black coatings on ped surfaces; violent effervescence with hydrogen peroxide; strongly acid; clear, wavy boundary. 6 to 10 inches thick.

B21—22 to 34 inches, dark reddish-brown (2.5YR 3/4) silty clay, dark red (2.5YR 3/6) when dry; strong, fine and very fine, subangular blocky structure; hard, firm, sticky and very plastic; few fine roots; many, fine and very fine, tubular pores; many sand-size aggregates that are resistant to crushing; continuous pressure cutans; common fine and very fine, black concretions; strong effervescence with hydrogen peroxide; neutral; clear, wavy boundary. 8 to 15 inches thick.

B22—34 to 47 inches, dark reddish-brown (2.5YR 3/4) silty clay, dark red (2.5YR 3/6) when dry; strong, fine and very fine, subangular blocky structure; hard, firm, sticky and very plastic; few fine roots; many, fine and very fine, tubular pores; continuous pressure cutans that look like slickensides; common sand-size aggregates that are resistant to crushing; many, fine and very fine, black concretions; common black coatings on ped surfaces; slight effervescence with hydrogen peroxide in matrix and violent effervescence on black coatings; neutral; clear, wavy boundary. 10 to 18 inches thick.

B3—47 to 61 inches, dark reddish-brown (2.5YR 3/4) silty clay, dark red (2.5YR 3/6) when dry; strong, very fine, subangular blocky structure; slightly hard, friable, sticky and very plastic; many coarse, medium, and fine tubular pores; continuous pressure cutans; common highly weathered pebbles that can be broken with the fingers; neutral.

The solum is more than 40 inches thick. The A horizon ranges from 2 to 3 in value when moist and, in chroma, from 2 to 4 when moist and 3 to 4 when dry. The B horizon ranges from 2.5YR to 10R in hue and from 3 to 4 in chroma when moist. The texture ranges from silty clay to clay.

This soil is used for sugarcane, pineapple, and homesites. (Capability classification IIIe, irrigated or nonirrigated; pineapple group 6; pasture group 3; woodland group 1)

Kahana silty clay, 3 to 7 percent slopes (KbB).—On this soil, runoff is slow and the erosion hazard is slight.

This soil is used for sugarcane, pineapple, and homesites. (Capability classification IIe, irrigated or nonirrigated; pineapple group 5; pasture group 3; woodland group 1)

Kahana silty clay, 15 to 25 percent slopes (KbD).—On this soil, runoff is medium and the erosion hazard is moderate. Included in mapping were small areas of eroded soils where weathered rock fragments commonly occur in the surface layer.

This soil is used for sugarcane. Small acreages are used for pineapple. (Capability classification IVe, irrigated or nonirrigated; pineapple group 6; pasture group 3; woodland group 1)

Kahanui Series

This series consists of well drained and moderately well drained soils on uplands on the islands of Molokai and Lanai. These soils developed in material weathered from basic igneous rock. They are gently sloping to moderately steep. Elevations range from 1,250 to 3,750 feet. The annual rainfall amounts to 60 to 80 inches, except on Lanai. Although actual precipitation amounts to only 35 inches on Lanai, effective rainfall amounts to 60 to 80 inches because fog and cloud cover are common. The rainfall is distributed fairly well throughout the year. The mean annual soil temperature is 62° F. Kahanui soils are geographically associated with Olelo and Olokui soils.

These soils are used for woodland, pasture, wildlife habitat, and water supply. The natural vegetation consists of hilograss, sweet vernalgrass, Boston fern, ohia, false staghornfern, and amaumau fern.

Kahanui gravelly silty clay, 3 to 20 percent slopes (KATD).—This soil occurs on ridgetops on the upper slopes of East Molokai. The surface layer is gravelly because of ironstone fragments.

In a representative profile the surface layer, about 15 inches thick, is dark-brown silty clay that has granular and subangular blocky structure. It has many ironstone concretions and fragments. The subsoil, 9 to 13 inches thick, is dark yellowish-brown and dark-brown silty clay and clay that has subangular blocky structure. The substratum is soft, weathered rock. A discontinuous ironstone sheet is at a depth of 12 to 24 inches. The soil is very strongly acid throughout the profile.

Permeability is moderately rapid above the ironstone sheet. Except for cracks, the ironstone sheet is impermeable. Runoff is slow to medium, and the erosion hazard is slight. At a depth of 12 to 24 inches, roots grow horizontally over the ironstone sheet. Trees growing on this soil tend to form a flat rooting system (fig. 4).

Representative profile: Island of Molokai, lat. 21°08′40″ N. and long. 156°57′21″ W.

A1—0 to 3 inches, dark-brown (10YR 3/3) gravelly silty clay, gray (10YR 5/1) when dry; strong, very fine to coarse, granular structure; hard, firm, sticky and plastic; many roots; many interstitial pores; many ironstone concretions as much as ½ inch long; many glistening specks; common worm casts; slight effervescence with hydrogen peroxide after a delay; moderately high bulk density; very strongly acid; abrupt, smooth boundary. 3 to 5 inches thick.

A3—3 to 15 inches, dark-brown (7.5YR 3/2) gravelly silty clay, grayish brown (10YR 5/2) when dry; dense slaglike layer breaking to weak, fine and medium, subangular blocky structure; hard, firm, very sticky and very plastic; few roots; many, very fine, tubular pores; many ironstone concretions as much as ¼ inch long; very high bulk density; slight efferves-

Figure 4.—Windblown tree on Kahanui gravelly silty clay. The soil has an ironstone sheet at a depth of 12 to 24 inches, and the tree roots developed laterally to form a flat rooting system.

cence with hydrogen peroxide; very strongly acid; abrupt, wavy boundary. 11 to 12 inches thick.

B21—15 to 21 inches, dark yellowish-brown (10YR 4/4), moist and dry, silty clay; moderate, very fine, subangular blocky structure; hard, friable, sticky and plastic; few roots; many, very fine, tubular pores; common elongated ironstone concretions, as much as 1 inch long, embedded horizontally throughout the horizon; very strongly acid; gradual, wavy boundary. 5 to 6 inches thick.

B22ir—21 to 25 inches, dark-brown (7.5YR 4/4), moist and dry, clay; moderate, very fine and fine, subangular blocky structure; hard, friable, very sticky and very plastic; few roots; many, very fine, tubular pores and common, fine and medium, tubular pores; few roots; at a depth of 22 inches there is a weakly developed ironstone sheet that is permeable to roots and water; very strongly acid; clear, wavy boundary. 4 to 7 inches thick.

C1—25 to 30 inches, soft saprolite, dark brown (10YR 3/3), brown (7.5YR 5/2), and gray (N 6/0) when moist; dark-brown mottles; this horizon has some original rock structure but breaks down to clay; hard, firm, sticky and plastic, and smeary; very strongly acid; abrupt, wavy boundary. 2 to 5 inches thick.

C2—30 to 60 inches, soft saprolite, yellowish red (5YR 4/6), reddish yellow (7.5YR 8/6), reddish brown (5YR 4/3), and dark gray (5YR 4/1) when moist; breaks down to gritty silt loam; hard, firm, slightly sticky and slightly plastic, and smeary; very strongly acid.

The amount of ironstone concretions and fragments in the A horizon ranges from 5 to 30 percent. In places the ironstone concretions and fragments form a slaglike mass to a depth of as much as 3 feet. The discontinuous ironstone sheet is slightly hard to very hard and ranges from 1/8 inch to 1 inch or more in thickness. In depressions it is hard or very hard, continuous, and impermeable to roots and water. Hard rock is at a depth of more than 5 feet. On concave slopes there are few, distinct, dark reddish-brown mottles in the upper part of the solum. The A horizon ranges from 7.5YR to 2.5Y in hue and, in value, from 3 to 4 when moist and 1 to 2 when dry. The B horizon ranges from 7.5YR to 10YR in hue, from 4 to 5 in value when moist, and from 4 to 6 in chroma when moist.

This soil is used mainly for woodland, wildlife habitat, and water supply. Small areas are used for pasture. (Capability classification VIe, nonirrigated; pasture group 8; woodland group 12)

Kahanui silty clay, 3 to 20 percent slopes (KASD).—This soil occurs on narrow ridgetops near the higher elevations on the island of Lanai. This soil has a profile like that of Kahanui gravelly silty clay on the island of Molokai, except that there are only a few ironstone concretions and fragments in the surface layer. There is considerable cloud cover during most of the afternoons and nights, and the soil receives much of its moisture in the form of fog drip. Because of this, the

soil under large trees is poorly drained. Gibbsite nodules are exposed in cuts and eroded areas.

This soil is used for water supply and wildlife habitat. (Capability classification VIe, nonirrigated; pasture group 8; woodland group 12)

Kailua Series

This series consists of well-drained soils on uplands on the island of Maui. These soils developed in volcanic ash. They are gently sloping to moderately steep. Elevations range from 200 to 2,000 feet. The annual rainfall amounts to 90 to 160 inches. It is well distributed throughout the year. The mean annual soil temperature is 70° F. Kailua soils are geographically associated with Pauwela soils.

These soils are used for pasture, woodland, and wildlife habitat. The natural vegetation consists of guava, hilograss, kaimiclover, kukui, and rattailgrass.

Kailua silty clay, 3 to 25 percent slopes (KBID).—This soil is on low uplands. Included in mapping were areas of Honomanu and Makawao soils. Also included were small, steep areas near cinder cones.

In a representative profile the surface layer is dark-brown silty clay about 9 inches thick. The upper part of the subsoil, about 18 inches thick, is dark-brown and dark reddish-brown silty clay that has subangular blocky structure. The lower part of the subsoil is very dark gray silty clay loam. The substratum is soft, weathered basic igneous rock. The soil is very strongly acid in the surface layer and strongly acid or medium acid in the subsoil.

Permeability is moderately rapid. Runoff is slow, and the erosion hazard is slight. In places roots penetrate to a depth of 4 feet or more.

Representative profile: Island of Maui, lat. 20°53′42″ N. and long. 156°14′58″ W.

Ap1—0 to 5 inches, dark-brown (10YR 3/3) silty clay, brown (10YR 4/3) when dry; strong, very fine and fine, subangular blocky structure; hard, friable, sticky and plastic, and weakly smeary; abundant fine and medium roots; many medium pores; few, fine, glistening specks; very strongly acid; clear, smooth boundary. 3 to 6 inches thick.

Ap2—5 to 9 inches, dark-brown (10YR 3/3) silty clay, brown (10YR 4/3) when dry; strong, fine and medium, subangular blocky structure; hard, friable, sticky and plastic, and weakly smeary; plentiful fine roots; many medium pores; few, fine, pale-yellow, pebble-size fragments; few glistening specks; few, fine, highly weathered, red rock fragments; very strongly acid; clear, smooth boundary. 4 to 6 inches thick.

B21—9 to 14 inches, dark-brown (7.5YR 3/2) silty clay, brown (7.5YR 4/3) when dry; moderate, fine and medium, subangular blocky structure; hard, friable, sticky and plastic, and weakly smeary; few fine roots; many medium and coarse pores; continuous, gelatinlike coatings on ped faces; few glistening specks; few, fine, hard, pale-yellow, pebble-size fragments; common hard rock fragments (1 millimeter to 3 millimeters); strongly acid; clear, wavy boundary. 4 to 8 inches thick.

B22—14 to 27 inches, dark reddish-brown (5YR 3/4) silty clay, reddish brown (5YR 4/4) when dry; moderate, fine and medium, subangular blocky structure; hard, friable, sticky and plastic, and moderately smeary; few fine roots; common medium pores; continuous, thick, gelatinlike coatings on ped faces; few, pale-yellow, pebble-size fragments; medium acid; clear, wavy boundary. 8 to 16 inches thick.

IIB23—27 to 40 inches, very dark gray (10YR 3/1) silty clay loam, dark gray (10YR 4/1) when dry; moderate, medium, subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic, and weakly smeary; few fine roots; common, hard, pale-yellow, pebble-size fragments; many dark-brown and reddish-brown highly weathered basalt fragments; medium acid.

The depth to weathered rock is more than 40 inches. In places a few stones occur on the surface. The A horizon ranges from 5YR to 10YR in hue, from 3 to 4 in value when dry, and from 2 to 3 in chroma when moist and 3 to 4 when dry. The B horizon ranges from 5YR to 10YR in hue, from 3 to 4 in value, and from 1 to 4 in chroma when moist. The B horizon dehydrates irreversibly into black and brown, sharp, angular, very hard, and fine, pebble-size aggregates.

This soil is used for pasture, woodland, and wildlife habitat. (Capability classification IVe, nonirrigated; pasture group 11; woodland group 8)

Kaimu Series

This series consists of well-drained, very shallow soils on uplands on the island of Maui. These soils developed in organic material. They are moderately sloping to moderately steep. Elevations range from 1,000 to 3,500 feet. The annual rainfall amounts to 30 to 50 inches. There is some afternoon cloud cover most of the year. The mean annual soil temperature is 68° F. Kaimu soils are geographically associated with Io and Kula soils.

These soils are used for pasture and wildlife habitat. The natural vegetation consists of black wattle, ilima, kikuyugrass, lantana, and molassesgrass.

Kaimu extremely stony peat, 7 to 25 percent slopes (KCXD).—This soil is on rough, undulating, relatively young Aa lava flows. Included in mapping were small areas of Io and Kula soils. Outcrops of Aa lava are common.

In a representative profile the surface layer is extremely stony black peat about 8 inches thick. The substratum is fragmental Aa lava that has a little soil material in voids and cracks. The soil is neutral in reaction.

Permeability is very rapid. Runoff is very slow, and the erosion hazard is no more than slight. In places roots penetrate to a depth of 2 feet.

Representative profile: Island of Maui, lat. 20°41′56″ N. and long. 156°22′37″ W.

1—0 to 8 inches, black (5YR 2/1) extremely stony peat, dark reddish brown (5YR 3/2) when dry; weak, very fine, granular structure; soft, very friable, nonsticky and nonplastic; abundant roots; porous; high in organic-matter content; low bulk density; 50 to 70 percent gravel, cobblestones, and stone-size fragments of Aa lava; neutral; clear, irregular boundary. 2 to 8 inches thick.

IIC—8 to 20 inches, fragmental Aa lava that contains a little soil material from the overlying horizon in cracks; abundant roots in cracks; organic matter and soil material decrease with depth.

The layer of peat ranges from 2 to 8 inches in thickness. It ranges from 5YR to 10YR in hue and from 1 to 2 in chroma when moist.

This soil is used for pasture and wildlife habitat. (Capability classification VIs, nonirrigated; pasture group 5; woodland group 3)

Kaipoioi Series

This series consists of well-drained soils on uplands on the island of Maui. These soils developed in volcanic ash and in material weathered from cinders. They are moderately sloping to steep. Elevations range from 3,500 to 6,000 feet. The annual rainfall amounts to 30 to 45 inches. Afternoon cloud cover is common most of the year. The mean annual soil temperature is 56° F. Kaipoioi soils are geographically associated with Laumaia, Olinda, Pane, and Kula soils.

These soils are used for pasture and wildlife habitat. The natural vegetation consists of kikuyugrass, rattailgrass, sweet vernalgrass, white clover, and Yorkshire foggrass.

Kaipoioi loam, 7 to 40 percent slopes (KDIE).—This soil is on smooth to rolling high mountain slopes. Included in mapping were small areas of Laumaia and Olinda soils and a few scattered rock outcrops.

In a representative profile the surface layer is black loam about 10 inches thick. The subsoil, about 51 inches thick, is black and very dark brown silt loam or silty clay loam that has subangular blocky structure. The substratum is ash and cinders. The soil is neutral in the surface layer and mildly alkaline to neutral in the subsoil.

Permeability is moderately rapid. Runoff is slow to medium, and the erosion hazard is slight to moderate. The available water capacity is about 2.6 inches per foot in the surface layer and about 1.6 inches per foot in the subsoil. In places roots penetrate to a depth of 60 inches or more.

Representative profile: Island of Maui, lat. 20°46′04″ N. and long. 156°17′34″ W.

Ap—0 to 5 inches, black (10YR 2/1) loam, very dark brown (10YR 2/2) when dry; strong, fine and very fine, granular structure; soft, very friable, nonsticky and nonplastic; abundant fine and very fine roots; many, very fine, interstitial pores; many sand-size aggregates that are more resistant than the matrix; neutral; clear, wavy boundary. 4 to 6 inches thick.

A1—5 to 10 inches, black (10YR 2/1) loam, very dark brown (10YR 2/2) when dry; strong, fine and very fine, granular structure; slightly hard, very friable, nonsticky and nonplastic; abundant fine and very fine roots; many very fine pores; many, hard, sand-size aggregates that are resistant to crushing; neutral; clear, wavy boundary. 4 to 7 inches thick.

B21—10 to 17 inches, black (10YR 2/1) silt loam, very dark grayish brown (10YR 3/2) when dry; weak, fine, subangular blocky structure; hard, very friable, slightly sticky and slightly plastic; abundant fine roots; many fine and very fine pores; thin, patchy, gelatinlike coatings on peds; mildly alkaline; gradual, wavy boundary. 6 to 8 inches thick.

B22—17 to 30 inches, very dark brown (10YR 2/2) silty clay loam, dark brown (10YR 3/3) when dry; weak, medium and fine, subangular blocky structure; hard, very friable, slightly sticky and plastic; plentiful fine roots; many fine pores; thin, patchy, gelatinlike coatings on peds; neutral; gradual, wavy boundary. 10 to 13 inches thick.

B23—30 to 45 inches, very dark brown (10YR 2/2) silty clay loam, dark brown (10YR 3/3) when dry; weak, medium and fine, subangular blocky structure; slightly hard, very friable, slightly sticky and plastic; few fine and very fine roots; many fine and very fine pores; thin, patchy, gelatinlike coatings on peds; neutral; gradual, wavy boundary. 13 to 17 inches thick.

B24—45 to 61 inches, very dark brown (10YR 2/2) silty clay loam, dark brown (10YR 3/3) when dry; moderate, fine and very fine, subangular blocky structure; hard, friable, slightly sticky and plastic; few fine roots; many fine and very fine pores; thin, nearly continuous, gelatinlike coatings on peds; gritty feel that disappears when rubbed; neutral.

The depth to bedrock is more than 60 inches. The A horizon ranges from 5YR to 10YR in hue. In places dusky-red ash and cinder layers, 2 to 4 inches thick, occur in the A horizon. The B horizon ranges from 5YR to 10YR in hue; from 2 to 3 in value when moist; and, in chroma, from 1 to 2 when moist and 2 to 4 when dry. The B horizon ranges from silt loam to silty clay loam in texture.

This soil is used for pasture and wildlife habitat. (Capability classification VIe, nonirrigated; pasture group 13; woodland group 11)

Kaipoioi very rocky loam, 7 to 40 percent slopes (KDVE).—This soil is similar to Kaipoioi loam, 7 to 40 percent slopes, except that rock outcrops cover 10 to 25 percent of the surface. Workability is very difficult. Included in mapping were small, very steep areas and small, eroded spots.

This soil is used for pasture and wildlife habitat. (Capability classification VIs, nonirrigated; pasture group 13; woodland group 11)

Kalae Series

This series consists of well-drained soils on uplands on the islands of Molokai and Lanai. These soils developed in material weathered from basic igneous rock. They are gently sloping to steep. Elevations range from 750 to 2,200 feet. The annual rainfall amounts to 30 to 50 inches; most of it occurs from November to April. The mean annual soil temperature is 70° F. Kalae soils are generally upslope from Lahaina soils.

These soils are used for pineapple and pasture. The natural vegetation consists of guava, lantana, hilograss, yellow foxtail, Natal redtop, and kikuyugrass.

Kalae silty clay, 2 to 7 percent slopes (KcB).—This soil is gently sloping and occupies smooth uplands. On Lanai, small areas were included where the slope is as much as 10 percent.

In a representative profile the surface layer is dark reddish-brown silty clay about 15 inches thick. The upper part of the subsoil, about 26 inches thick, is dark-red silty clay that has subangular blocky structure. It is compact in place. The lower part, about 21 inches thick, is dark-red and reddish-brown silt loam. The substratum is dark-brown silt loam and soft, weathered rock. The soil is strongly acid throughout the profile.

Permeability is moderately rapid. Runoff is slow, and the erosion hazard is slight. The available water capacity is about 1.4 inches per foot in the surface layer and about 1.6 inches per foot in the subsoil. In places roots penetrate to a depth of 5 feet or more.

Representative profile: Island of Molokai, lat. 21°10′28″ N. and long. 157°02′37″ W.

Ap1—0 to 9 inches, dark reddish-brown (2.5YR 3/4) silty clay, weak red (2.5YR 4/2) when dry; cloddy, breaking to moderate, very fine to medium, granular structure; hard, friable, sticky and plastic; few roots; moderately high bulk density; common, hard, earthy lumps that break down when rubbed; slight effer-

vescence with hydrogen peroxide; strongly acid; abrupt, smooth boundary. 7 to 9 inches thick.

Ap2—9 to 15 inches, dark reddish-brown (2.5YR 3/4) silty clay, weak red (2.5YR 4/2) when dry; cloddy, breaking to weak, fine to coarse, subangular blocky structure; hard, friable, sticky and plastic; few roots; many, very fine and fine, tubular pores and few, medium, tubular pores; firm in place; moderately high bulk density; slight effervescence with hydrogen peroxide; strongly acid; clear, wavy boundary. 4 to 8 inches thick.

B21t—15 to 26 inches, dark-red (2.5YR 3/6) silty clay, red (2.5YR 4/6) when dry; strong, very fine and fine, subangular blocky structure; very hard, firm, sticky and plastic; few roots; few, very fine, tubular pores; thin, continuous clay films; many, hard, earthy lumps that break down after prolonged rubbing; compact in place; upper part of this horizon has pockets that are slightly smeary and very friable and are dark reddish brown (2.5YR 3/4) when moist; slight effervescence with hydrogen peroxide; strongly acid; gradual, wavy boundary. 7 to 15 inches thick.

B22t—26 to 41 inches, dark-red (2.5YR 4/6), moist and dry, silty clay; strong, very fine and fine, subangular blocky structure; very hard, firm, sticky and plastic; few roots; few, very fine, tubular pores; thin, continuous clay films on peds; many, hard, earthy lumps that break down after prolonged rubbing; compact in place; slight effervescence with hydrogen peroxide; strongly acid; clear, wavy boundary. 13 to 16 inches thick.

B31—41 to 53 inches, dark-red (2.5YR 3/6) silt loam; yellowish red (5YR 4/6, dry) when crushed; moderate, fine and very fine, subangular blocky structure; hard, friable, slightly sticky and slightly plastic; few roots; common, very fine, tubular pores and few, fine, tubular pores; few, patchy clay films; strongly acid; gradual, wavy boundary. 5 to 12 inches thick.

B32—53 to 62 inches, reddish-brown (5YR 4/4, moist) silt loam; moderate, fine and medium, subangular blocky structure; hard, friable, slightly sticky and slightly plastic; no roots; common, very fine and fine, tubular pores; dark illuviation cutans on ped faces; strongly acid; gradual, irregular boundary. 1 to 12 inches thick.

C—62 to 67 inches, dark-brown (10YR 3/3 and 7.5YR 3/4, moist) silt loam; weak, fine and very fine, subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; many, very fine, tubular pores; about 30 percent of this horizon is made up of soft, weathered rock; strongly acid.

The depth to bedrock is more than 5 feet. The upper part of the B horizon is mixed with the A horizon in most cultivated areas. The A horizon ranges from 2.5YR to 5YR in hue and, in chroma, from 4 to 5 when moist and 2 to 4 when dry. The B2t horizon ranges from 2.5YR to 10R in hue, from 3 to 4 in value when moist or dry, and from 3 to 6 in chroma when moist or dry.

This soil is used mainly for pasture and pineapple. (Capability classification IIe if irrigated, IIIc if nonirrigated; pineapple group 5; pasture group 6; woodland group 5)

Kalae silty clay, 7 to 15 percent slopes (KcC).—On this soil, runoff is slow to medium and the erosion hazard is slight to moderate.

This soil is used for pasture and pineapple. (Capability classification IIIe, irrigated or nonirrigated; pineapple group 6; pasture group 6; woodland group 5)

Kalae silty clay, 5 to 15 percent slopes, severely eroded (KcC3).—This soil occurs on Molokai. It has a profile like that of Kalae silty clay, 2 to 7 percent slopes, except that most of the surface layer and in places part of the subsoil have been removed by erosion. In many places gravelly, relatively soft rock fragments have been brought into the surface layer through cultivation and erosion. Runoff is medium, and the erosion hazard is moderate to severe. Included in mapping were small areas where the slope is less than 5 percent.

This soil is used mostly for pasture; small areas are used for pineapple. (Capability classification IVe, irrigated or nonirrigated; pineapple group 6; pasture group 6; woodland group 5)

Kalae silty clay, 15 to 25 percent slopes, severely eroded (KcD3).—This soil occurs as narrow areas on sharp slope breaks. It has a profile like that of Kalae silty clay, 2 to 7 percent slopes, except that most of the surface layer and, in places, part of the subsoil have been removed by erosion. In cultivated fields the plow layer consists of a mixture of soil material and gravelly, relatively soft rock fragments. Runoff is rapid, and the erosion hazard is severe. Workability is difficult because of moderately steep slopes.

Although suitability is marginal, this soil is used for pineapple where it occurs in association with less sloping Kalae and Lahaina soils. It is also used for pasture. (Capability classification VIe, irrigated or nonirrigated; pasture group 6; woodland group 5)

Kalae silty clay, 25 to 40 percent slopes, severely eroded (KcE3).—Nearly all of this soil occurs near the golf course on West Molokai. It is on steep ridges and sides of the gulches. It has a profile like that of Kalae silty clay, 2 to 7 percent slopes, except that the surface layer and part of the subsoil have been removed by erosion. Runoff is rapid to very rapid, and the erosion hazard is very severe. There are bare spots that are difficult to vegetate because of strong winds and low fertility. There are a few gullies.

This soil is used for pasture and wildlife habitat. (Capability classification VIe, nonirrigated; pasture group 6; woodland group 5)

Kalapa Series

This series consists of well-drained soils at the base of slopes on the island of Kauai. These soils developed in material weathered from basic igneous rock and in colluvium. They are moderately sloping to very steep. Elevations range from 200 to 1,200 feet. The annual rainfall amounts to 60 to 100 inches. The mean annual soil temperature ranges from 69° to 74° F. Kalapa soils are geographically associated with Hihimanu and Hanamaulu soils.

These soils are used mainly for water supply, woodland, wildlife habitat, and pasture. A small acreage is used for irrigated sugarcane. The natural vegetation consists of guava, lantana, joee, sensitiveplant, pilipiliula, ohia, Japanese tea, and ferns.

Kalapa silty clay, 40 to 70 percent slopes (KdF).—This soil is on uplands.

In a representative profile the surface layer is dark reddish-brown silty clay about 10 inches thick. The subsoil, about 40 inches thick, ranges from dark-red to dark reddish-brown silty clay and clay that has subangular blocky structure. The substratum is dark-brown, dusky-red, and dark-red silty clay and soft, highly weathered

rock. The soil is very strongly acid throughout the profile.

Permeability is moderately rapid. Runoff is very rapid, and the erosion hazard is severe to very severe. In places roots penetrate to a depth of 5 feet or more.

Representative profile: Island of Kauai, lat. 21°55′14″ N. and long. 159°26′00.3″ W.

A1—0 to 10 inches, dark reddish-brown (5YR 3/3), moist and dry, silty clay; moderate, fine, subangular blocky structure; very hard, firm, sticky and plastic; plentiful fine and very fine roots; slight effervescence with hydrogen peroxide; very strongly acid; abrupt, wavy boundary. 8 to 12 inches thick.

B21t—10 to 20 inches, dark-red (2.5YR 3/6) silty clay, reddish brown (2.5YR 4/4) when dry; weak, fine and very fine, subangular blocky structure; very hard, firm, sticky and plastic; few medium, and plentiful fine and very fine roots; many fine and very fine pores; nearly continuous, thin clay films; upper 4 to 5 inches mixed with material from the A horizon by earthworms; very strongly acid; clear, wavy boundary. 8 to 11 inches thick.

B22t—20 to 37 inches, dark-red (2.5YR 3/6) clay that exhibits bands of weak red (2.5YR 4/2), reddish brown (2.5YR 4/4) when dry; moderate, very fine, subangular blocky structure; very hard, firm, very sticky and plastic; few medium, fine, and very fine roots; many fine and very fine pores; continuous, thin clay films; very strongly acid; clear, smooth boundary. 15 to 19 inches thick.

B23t—37 to 44 inches, dark-red (2.5YR 3/6) clay, red (2.5YR 4/6) when dry; red, white, and yellow sand-size particles; moderate, fine and very fine, subangular blocky structure; very hard, firm, very sticky and plastic; few fine and very fine roots; many fine and very fine pores; continuous, moderately thick clay films; very strongly acid; clear, smooth boundary. 6 to 8 inches thick.

B24t—44 to 50 inches, dark reddish-brown (5YR 3/4) gravelly clay, dark reddish brown (2.5YR 3/4) when dry; moderate, fine and very fine, subangular blocky structure; very hard, firm, very sticky and plastic; few fine roots; common fine and very fine pores; nearly continuous, moderately thick clay films; gravel is highly weathered; very strongly acid; clear, smooth boundary. 4 to 7 inches thick.

C—50 to 60 inches, dark-brown (7.5YR 3/2), dusky-red (10R 3/2), and dark-red (10R 3/6) silty clay; weak red (10R 4/2) when dry; many, fine, red and white, sand-size particles; weak, fine and very fine, subangular blocky structure; very hard, firm, very sticky and very plastic; no roots; few fine and very fine pores; patchy, moderately thick clay films; very strongly acid.

The A horizon ranges from 5YR to 7.5YR in hue and from 2 to 4 in chroma. The B horizon ranges from 2.5YR to 5YR in hue, from 3 to 4 in value, and from 3 to 6 in chroma. The depth to soft, highly weathered rock ranges from 40 inches to more than 60 inches. In places a few stones and boulders occur throughout the solum.

This soil is used for water supply, pasture, and woodland. (Capability classification VIIe, nonirrigated; pasture group 8; woodland group 14)

Kalapa silty clay, 20 to 40 percent slopes (KdE).—On this soil, runoff is rapid and the erosion hazard is severe.

This soil is used for pasture, water supply, wildlife habitat, and woodland. A small acreage is used for sugarcane. (Capability classification VIe, nonirrigated; pasture group 8; woodland group 7)

Kalapa silty clay, 8 to 20 percent slopes (KdD).—On this soil, runoff is medium and the erosion hazard is moderate.

This soil is used for sugarcane, pasture, wildlife habitat, and woodland. (Capability classification IVe, irrigated or nonirrigated; sugarcane group 2; pasture group 8; woodland group 7)

Kalapa very rocky silty clay, 40 to 70 percent slopes (KEHF).—This soil is similar to Kalapa silty clay, 40 to 70 percent slopes, except that 10 to 40 percent of the acreage is covered by rock outcrop. Runoff is very rapid, and the erosion hazard is severe to very severe.

This soil is used for water supply, pasture, and woodland. (Capability classification VIIs, nonirrigated; pasture group 8; woodland group 14)

Kalaupapa Series

This series consists of well-drained upland soils underlain by pahoehoe bedrock at a depth of about 14 inches. These soils occur on the Kalaupapa peninsula on the island of Molokai (fig. 5). They developed in relatively recent volcanic ash. They are gently sloping to moderately steep. Elevations range from nearly sea level to 400 feet. The annual rainfall amounts to 35 to 50 inches. The mean annual soil temperature is 74° F. Kalaupapa soils are geographically associated with Haleiwa and Jaucas soils.

These soils are used for pasture. The natural vegetation consists of lantana, guava, bermudagrass, kukaipuaa, joee, and Java plum.

Kalaupapa very rocky silty clay loam, 3 to 25 percent slopes (KFID).—This soil occurs as one large area. It is shallow, and there are many stones and cobblestones on the surface and few to many in the profile. Rock outcrops cover about 15 percent of the surface.

In a representative profile the surface layer is dark-brown silty clay loam about 6 inches thick. The subsoil, about 8 inches thick, is dark yellowish-brown, nearly massive silt loam. Hard pahoehoe bedrock occurs at a depth of about 14 inches. The soil is neutral throughout the profile.

Permeability is moderately rapid. Runoff is slow to medium, and the erosion hazard is slight to moderate. Roots penetrate to the bedrock. Cultivation is impractical because of shallowness, the many stones, and the rock outcrops.

Representative profile: Island of Molokai, lat. 21°11′28″ N. and long. 156°57′42″ W.

A1—0 to 6 inches, dark-brown (10YR 3/3 moist, 4/3 dry) silty clay loam; strong, fine and medium, granular structure; hard, firm, sticky and plastic; many roots; many interstitial pores; few to common pebbles and stones; moderate effervescence with hydrogen peroxide; neutral; clear, smooth boundary. 4 to 6 inches thick.

B2—6 to 14 inches, dark yellowish-brown (10YR 3/4 moist, 4/4 dry) silt loam; weak, fine, subangular blocky structure to massive; soft, very friable, slightly sticky and slightly plastic; common roots; many, very fine, tubular pores and common, fine, tubular pores; common pebbles; loose in place; slight effervescence with hydrogen peroxide; neutral; abrupt, wavy boundary. 3 to 12 inches thick.

IIR—14 inches, hard pahoehoe bedrock.

The depth to pahoehoe bedrock is typically about 14 inches, but it ranges from 7 to 18 inches. The A and B horizons range from 7.5YR to 10YR in hue. The texture of the A horizon is typically silty clay loam, but in a few areas

Figure 5.—Soils of the Kalaupapa series. These soils formed in ash from lava that erupted from the volcanic crater at upper right.

It is silt loam. The texture of the B horizon ranges from silty clay loam to silt loam.

This soil is used for pasture. Most of the pastures are unimproved, and much of the area is covered with lantana. Mechanical clearing of brush is difficult. (Capability classification VIIs, nonirrigated; pasture group 5; woodland group 13)

Kalihi Series

This series consists of poorly drained soils on bottom lands on the island of Kauai. These soils developed in alluvium derived from basic igneous materials. They are nearly level. Elevations range from 50 to 100 feet. The annual rainfall amounts to 40 to 60 inches. The mean annual soil temperature is 74° F. Kalihi soils are geographically associated with Kaena and Waikomo soils.

These soils are used for irrigated sugarcane. All of the soils are cultivated.

Kalihi clay (Ke).—This soil is on bottom lands.

In a representative profile the surface layer is dark-brown and very dark grayish-brown, mottled clay about 16 inches thick. The subsoil, about 30 inches thick, is dark-gray, mottled, massive clay. The substratum is mottled, grayish-brown and dark-gray clay. The surface layer is neutral to slightly acid. The subsoil is slightly acid to strongly acid.

Permeability is slow. Runoff is slow, and erosion is not a hazard. The available water capacity is about 1.5 inches per foot of soil. Roots penetrate to a depth of 60 inches. Workability is difficult.

Representative profile: Island of Kauai, lat. 21°54′13.4″ N. and long. 159°25′16.1″ W.

Ap1—0 to 8 inches, dark-brown (10YR 3/3) clay, dark gray (10YR 4/1) when dry; few, fine, distinct mottles of yellowish brown (10YR 5/6) and brown (10YR 5/3) and a few black stains; weak, fine, subangular blocky structure; very hard, firm, very sticky and very plastic; abundant roots; moderate effervescence with hydrogen peroxide; neutral; gradual, smooth boundary. 6 to 10 inches thick.

Ap2—8 to 16 inches, very dark grayish-brown (10YR 3/2) clay, very dark gray (10YR 3/1) when dry; few, fine, distinct mottles of yellowish brown and reddish brown; weak, fine, subangular blocky structure; extremely hard, firm, very sticky and very plastic; abundant roots; moderate effervescence with hydrogen peroxide; neutral; clear, smooth boundary. 6 to 10 inches thick.

B21g—16 to 27 inches, dark-gray (2Y 4/1) clay, grayish brown (10YR 5/2) when dry; common, medium, distinct mottles of yellowish brown, reddish brown, and yellowish red; massive; extremely hard, firm, very sticky and very plastic; abundant roots; many fine and very fine pores; slightly acid; gradual, smooth boundary. 9 to 12 inches thick.

B22g—27 to 46 inches, dark-gray (5Y 4/1) clay, gray (2.5Y 5/1) when dry; many, medium, distinct mottles of

strong brown, reddish brown, and yellowish red; massive; extremely hard, firm, very sticky and very plastic; plentiful roots; common very fine pores; strongly acid; gradual, smooth boundary. 17 to 21 inches thick.

C1g—46 to 60 inches, grayish-brown (2.5Y 5/2) and dark-gray (5Y 4/1) clay, gray (5Y 5/1) when dry; massive; extremely hard, firm, very sticky and very plastic; few roots; few fine pores; neutral; gradual, smooth boundary. 12 to 15 inches thick.

C2g—60 to 70 inches, dark-gray (5Y 4/1), olive-gray (5Y 5/2), and yellowish-brown (10YR 5/6) clay; olive (5Y 5/3) with mottles of brownish yellow (10YR 6/6) when dry; massive; extremely hard, firm, very sticky and very plastic; few roots; few very fine pores; slight effervescence with hydrogen peroxide; neutral.

The A horizon ranges from 2 to 3 in value and from 1 to 3 in chroma. Mottles range from none to few. The B horizon ranges from neutral to 2.5Y and 5Y in hue, from 4 to 5 in value, and from 0 to 1 in chroma. Mottles range from common to many.

This soil is used for irrigated sugarcane. (Capability classification IIIw if irrigated, IVw if nonirrigated; sugarcane group 3; pasture group 7; woodland group 4)

Kaloko Series

This series consists of poorly drained soils on coastal plains on the islands of Kauai and Oahu. These soils developed in alluvium derived from basic igneous rock; the alluvium has been deposited over marly lagoon deposits. The soils are nearly level. Elevations range from sea level to 20 feet. The annual rainfall amounts to 20 to 25 inches. The mean annual soil temperature is 73° F. Kaloko soils are geographically associated with Nohili soils on Kauai and with Keaau, Pearl Harbor, and Waialua soils on Oahu.

In this survey area a noncalcareous variant of the Kaloko series was mapped. This soil, Kaloko clay, noncalcareous variant, is described in alphabetical order, along with other mapping units of this series.

These soils are used for irrigated sugarcane and pasture. The natural vegetation consists of kiawe, klu, bermudagrass, and annuals.

Kaloko clay (Kfc).—This soil is nearly level and occurs on coastal plains. Included in the areas mapped on Oahu were small areas that consist mainly of coral fragments or marly material; areas of clayey, very poorly drained soils that are underlain by peat or muck; and small areas of dark reddish-brown, very deep, moderately well drained alluvial soils.

In a representative profile the surface layer is dark-brown clay about 12 inches thick. The subsoil, about 8 inches thick, is dark reddish-brown and weak-red clay. Below this is mottled, white to light-gray, platy silty clay about 13 inches thick. This is underlain by dark greenish-gray and dark-gray massive silty clay. The soil is mildly alkaline to neutral throughout the profile.

Permeability is moderately slow to slow. Runoff is slow to very slow, and the erosion hazard is no more than slight. The available water capacity is about 1.6 inches per foot of soil. Roots penetrate to a depth of about 40 inches or to the water table in undrained areas. Workability is somewhat difficult.

Representative profile: Island of Kauai, lat. 22°01′6.5″ N. and long. 159°46′10.1″ W.

Ap—0 to 12 inches, dark-brown (7.5YR 3/2) clay; common, fine, distinct, red mottles and yellowish-white specks; weak, fine, subangular blocky structure; very hard, firm, very sticky and very plastic; abundant roots; moderate reaction with hydrogen peroxide; violent reaction with hydrochloric acid; mildly alkaline; clear, smooth boundary. 8 to 15 inches thick.

B2—12 to 20 inches, dark reddish-brown (5YR 3/3) and weak-red (2.5YR 5/2) clay; many, fine, distinct mottles of brownish yellow (10YR 6/6), white (2.5Y 8/2), and reddish yellow (5YR 6/6); moderate, fine, angular and subangular blocky structure; very hard, firm, very sticky and very plastic; plentiful roots; many fine pores; thin, patchy coatings that look like illuviation cutans; slight reaction to hydrogen peroxide; violent reaction to hydrochloric acid; mildly alkaline; abrupt, smooth boundary. 7 to 11 inches thick.

IIC1g—20 to 29 inches, mottled white (2.5Y 8/1), reddish-brown (5YR 5/4), strong-brown (7.5YR 5/8), dark-brown (7.5YR 3/2), and gray (5Y 6/1) silty clay; rubbed color is light yellowish brown (2.5Y 6/3); weak, medium and thick plates; salt crystals between some plates; hard, firm, sticky and plastic; few roots; few fine and medium pores; violent reaction to hydrochloric acid; mildly alkaline; abrupt, smooth boundary. 8 to 11 inches thick.

IIC2sag—29 to 33 inches, layers of light-gray (N 6/0), gray (N 5/0), dark-gray (5Y 4/1), pink (7.5YR 8/4), grayish-brown (2.5Y 5/2), and reddish-brown (5YR 4/4) silty clay; rubbed color is olive gray (5Y 5/2); moderate, medium and thick plates; hard, friable, sticky and plastic; few roots; few fine pores; salt crystals make up about 50 percent of volume; neutral; abrupt, smooth boundary. 12 to 15 inches thick.

IIIC3g—33 to 43 inches, thickest plates are dark greenish-gray (5BG 4/1) silty clay; other plates are dark-gray (N 4/0), gray (5Y 5/1), and light-gray (5Y 6/1) silty clay; rubbed color is dark greenish gray (5BG 4/1); moderate, thin and thick plates; hard, friable, sticky and plastic; few roots; common fine and medium pores; moderate effervescence with hydrochloric acid; neutral; abrupt, smooth boundary. 9 to 11 inches thick.

IIIC4sag—43 to 60 inches, dark greenish-gray (5BG 4/1), light greenish-gray (5GY 7/1), greenish-gray (5GY 6/1), and dark greenish-gray (5GY 4/1) silty clay; rubbed color is greenish gray (5BG 5/1); massive; friable, sticky; common salt crystals; moderate effervescence with hydrochloric acid; mildly alkaline.

The A horizon ranges from 5YR to 7.5YR in hue and from 1 to 2 in chroma. Mottles in the A horizon range from few to common. The B horizon ranges from 2.5YR to 10YR in hue and from 2 to 4 in chroma. The depth to the light-colored calcareous C horizon ranges from 12 to 20 inches. The depth to the water table varies, because all the soils are artificially drained. Unless the soils are drained, the water table generally is at a depth of 12 to 20 inches.

This soil is used for irrigated sugarcane and pasture. (Capability classification IIIw if irrigated, Vw if nonirrigated; sugarcane group 3; pasture group 7)

Kaloko clay loam (Kf).—This soil is on the Mana plain on the island of Kauai. This soil has a profile like that of Kaloko clay, except for the texture of the surface layer and horizontal lenses of sand in the underlying material. It is easier to work than that soil. Runoff is very slow, and there is no hazard of erosion.

This soil is used for sugarcane. (Capability classification IIIw if irrigated, Vw if nonirrigated; sugarcane group 3; pasture group 7)

Kaloko clay, noncalcareous variant (Kfb).—This soil occurs in slight depressions on the coastal plains on the island of Oahu. It is more acid and grayer than is typical

of the Kaloko series. It is underlain by noncalcareous material. The annual rainfall amounts to 40 to 60 inches.

The surface layer is very dark gray clay. The subsoil is gray or grayish-brown prismatic clay. The substratum is massive clay and silty clay. This soil is slightly acid to neutral throughout.

Included in mapping were small areas of very deep, well-drained alluvial soils in drainageways.

Permeability is slow. Runoff is ponded to very slow, and the erosion hazard is none to slight. The available water capacity is 1.6 inches per foot of soil. In places roots penetrate to a depth of 5 feet or more.

This soil is used for pasture and sugarcane. (Capability classification IIIw if irrigated, Vw if nonirrigated; sugarcane group 3; pasture group 7)

Kamaole Series

This series consists of well-drained soils on uplands on the island of Maui. These soils developed in volcanic ash. They are gently to moderately sloping. Elevations range from 1,500 to 2,300 feet. The annual rainfall amounts to 15 to 25 inches; most of it occurs in winter. The mean annual soil temperature is 69° F. Kamaole soils are geographically associated with Kaimu, Keawakapu, Kula, and Waiakoa soils.

These soils are used for pasture and wildlife habitat. The natural vegetation consists of bermudagrass, castorbean, false mallow, feather fingergrass, and kiawe.

Kamaole very stony silt loam, 3 to 15 percent slopes (KGKC).—This soil is on uplands. Included in mapping were small areas of Keawakapu and Kula soils. Also included were small areas where slopes have been removed. Outcrops of Aa lava are common.

In a representative profile the surface layer is dark-brown and dark reddish-brown silt loam and silty clay loam about 8 inches thick. The subsoil, about 12 inches thick, is dark reddish-brown silty clay that has subangular blocky structure. The substratum is fragmental Aa lava that has very little soil material in voids. The soil is medium acid and slightly acid in the surface layer and mildly alkaline in the subsoil.

Permeability is moderate. Runoff is slow to medium, and the erosion hazard is slight to moderate. The available water capacity is about 1.2 inches per foot in the surface layer and subsoil. In places roots penetrate to a depth of 2 feet.

Representative profile: Island of Maui, lat. 20°45′00″ N. and long. 156°21′44″ W.

A11—0 to 2 inches, dark-brown (10YR 3/3) very stony silt loam, brown (10YR 4/3) when dry; moderate, thin and very thin, platy structure; soft, friable, slightly sticky and slightly plastic; abundant fine roots that have a tendency to mat on plate faces; common fine pores; few, fine, black concretions; 10 to 15 percent stones; slight effervescence with hydrogen peroxide; medium acid; abrupt, smooth boundary. 1 to 3 inches thick.

A12—2 to 8 inches, dark reddish-brown (5YR 3/2) silty clay loam, dark reddish gray (5YR 4/2) when dry; moderate, fine and very fine, subangular blocky structure; slightly hard, friable, sticky and plastic; plentiful fine roots; many fine and very fine pores; few, fine, black concretions; few moderately weathered pebbles; slight effervescence with hydrogen peroxide; slightly acid; gradual, wavy boundary. 4 to 7 inches thick.

B2—8 to 20 inches, dark reddish-brown (5YR 3/2) cobbly silty clay, dark reddish brown (5YR 3/3) when dry; moderate, very fine and fine, subangular blocky structure; hard, firm, very sticky and very plastic; few roots; many fine pores; few, fine, black concretions; thin, patchy clay films on peds; few sand-size aggregates that are more resistant than the matrix; 10 to 20 percent weathered gravel and cobblestones; strong effervescence with hydrogen peroxide; mildly alkaline; clear, wavy boundary. 10 to 14 inches thick.

IIC—20 inches, fragmental Aa lava that contains a little soil material in voids.

The depth to fragmental Aa lava ranges from 16 to 24 inches. The A horizon ranges from 5YR to 10YR in hue, from 2 to 3 in value when moist and 3 to 4 when dry, and from 2 to 3 in chroma when moist and 2 to 4 when dry. The texture is silt loam or silty clay loam. The B horizon ranges from 5YR to 7.5YR in hue and from 2 to 3 in value when moist. The texture is silty clay loam or silty clay.

This soil is used for pasture and wildlife habitat. (Capability classification VIs, nonirrigated; pasture group 3)

Kamaole extremely stony silt loam, 3 to 15 percent slopes (KGLC).—This soil is similar to Kamaole very stony silt loam, 3 to 15 percent slopes, except that stones cover 3 to 15 percent of the surface. Included in mapping were small areas of rock outcrop.

This soil is used for pasture and wildlife habitat. (Capability classification VIs, nonirrigated; pasture group 3)

Kaneohe Series

This series consists of well-drained soils on terraces and alluvial fans on the windward side of Oahu. These soils developed in alluvium and colluvium derived from basic igneous rock. In a few places they developed in volcanic ash and in material weathered from cinders. The soils are gently sloping to very steep. Elevations range from 100 to 1,000 feet. The annual rainfall, which is fairly well distributed throughout the year, amounts to 70 to 90 inches. The mean annual soil temperature is 71° F. Kaneohe soils are geographically associated with Alaeloa, Lolekaa, and Waikane soils.

These soils are used for pasture, homesites, and urban development. The natural vegetation consists of guava, Boston fern, sensitive plant, glenwoodgrass, and hilograss.

Kaneohe silty clay, 3 to 8 percent slopes (KgB).—This soil occupies uniform slopes. Included in mapping were small areas of reddish-colored soils and areas of dark-brown soils that formed in gravelly alluvium.

In a representative profile the surface layer is dark reddish-brown silty clay about 14 inches thick. The subsoil, 40 to more than 50 inches thick, is dusky-red and dark-red silty clay that has subangular blocky structure. The substratum is soft, weathered gravel. The soil is slightly acid in the surface layer and strongly acid in the subsoil.

Permeability is moderately rapid. Runoff is slow to medium, and the erosion hazard is slight. The available water capacity is 1.2 inches per foot in the surface layer and 1.4 inches per foot in the subsoil. In places roots penetrate to a depth of 5 feet or more.

Representative profile: Island of Oahu, lat. 21°22′44″ N. and long. 157°47′36″ W.

Ap—0 to 14 inches, dark reddish-brown (2.5YR 3/4) silty clay, reddish brown (2.5YR 4/4) when dry; strong, very fine, subangular blocky structure; very hard, firm, sticky and plastic; abundant very fine and fine, and few medium roots; many, very fine and fine, tubular and interstitial pores; common wormholes and worm casts; few, soft, highly weathered pebbles; slightly acid; clear, wavy boundary. 8 to 14 inches thick.

B21—14 to 22 inches, dusky-red (10R 3/4) silty clay, dark red (10R 3/6) when dry; weak, very fine and fine, subangular blocky structure; hard, friable, sticky and plastic; abundant very fine and fine, and few medium roots; many, very fine and fine, tubular pores and few, medium, tubular pores; common, soft, strong-brown, yellow, and gray, highly weathered pebbles; thin, patchy clay films on ped faces; strongly acid; gradual, smooth boundary. 7 to 12 inches thick.

B22—22 to 34 inches, dark-red (2.5YR 3/4) silty clay, red (2.5YR 4/6) when dry; weak, very fine and fine, subangular blocky structure; hard, friable, slightly sticky and slightly plastic, and smeary; plentiful fine roots; many, very fine and fine, tubular pores; common highly weathered rock fragments; thin, patchy clay films on peds and in pores; strongly acid; gradual, wavy boundary. 10 to 14 inches thick.

B23t—34 to 60 inches, dusky-red (10R 3/4) silty clay, dark red (2.5YR 3/6) when moist; strong, fine, blocky and subangular blocky structure; hard, friable, sticky and slightly plastic, and smeary; few fine roots; many, very fine and fine, tubular pores; thin, patchy clay films on peds; common highly weathered rock fragments and a few hard boulder cores; strongly acid.

Weathered gravel makes up 5 to 25 percent of the soil mass and increases in size, amount, and hardness with depth. The A horizon ranges from 5YR to 10R in hue, from 2 to 4 in chroma, and, in value, from 3 to 6 when dry. The B horizon ranges from 3 to 4 in value when moist or dry, and from 4 to 6 in chroma when moist or dry. The B horizon ranges from slightly plastic to plastic in consistence. This soil tends to dehydrate irreversibly upon drying, particularly in the B horizon. The B23t ranges from silty clay to silty clay loam in texture.

This soil is used for pasture and golf courses. (Capability classification IIe, nonirrigated; pasture group 8; woodland group 7)

Kaneohe silty clay, 8 to 15 percent slopes (KgC).—On this soil, runoff is medium and the erosion hazard is moderate. Included in mapping were small eroded spots and gravelly areas.

This soil is used for pasture. (Capability classification IIIe, nonirrigated; pasture group 8; woodland group 7)

Kaneohe silty clay, 30 to 65 percent slopes (KHOF).—This soil occurs on terrace faces and along drainageways. Runoff is medium to rapid, and the erosion hazard is moderate to severe. Workability is difficult because of the slope. Included in mapping were small eroded spots and gravelly areas. Also included were small areas where the slope is less than 30 percent.

This soil is used for pasture. (Capability classification VIIe, nonirrigated; pasture group 8; woodland group 14)

Kaneohe silty clay loam, 5 to 15 percent slopes (KHMC).—This soil has a profile like that of Kaneohe silty clay, 3 to 8 percent slopes, except that the texture throughout the profile is silty clay loam. There are large amounts of volcanic ash and cinders in the subsoil. Volcanic ash and cinders generally occur below a depth of 20 inches. The soil is extremely acid to very strongly acid. Included in mapping were small eroded spots, gravelly areas, and steep slopes.

This soil is used for pasture and homesites. (Capability classification IIIe, nonirrigated; pasture group 8; woodland group 7)

Kaneohe silty clay loam, 15 to 30 percent slopes (KHME).—This soil has a profile like that of Kaneohe silty clay, 3 to 8 percent slopes, except that the texture throughout the profile is silty clay loam. There are considerable amounts of volcanic ash and cinders in the subsoil. Volcanic ash and cinders generally occur below a depth of 20 inches. Runoff is medium to rapid, and the erosion hazard is moderate to severe. Workability is difficult because of the slope. The soil is extremely acid to very strongly acid.

This soil is used for pasture. (Capability classification VIe, nonirrigated; pasture group 8; woodland group 7)

Kaneohe silty clay loam, 30 to 65 percent slopes (KHMF).—This soil has a profile like that of Kaneohe silty clay, 3 to 8 percent slopes, except that the texture throughout the profile is silty clay loam. Large amounts of volcanic ash and cinders occur at a depth below 20 inches. Runoff is medium to rapid, and the erosion hazard is moderate to severe. Included in mapping were small eroded spots, gravelly areas, and small stony areas where the slope is up to 70 percent.

This soil is used for pasture. (Capability classification VIIe, nonirrigated; pasture group 8; woodland group 14)

Kanepuu Series

This series consists of well-drained soils on uplands on the island of Lanai. These soils formed in material derived from basic igneous rock. They are gently sloping and moderately sloping. Elevations range from 1,500 to 2,000 feet. The annual rainfall amounts to 20 to 25 inches, most of which occurs from November to April. In most places these soils are exposed to strong trade winds. The mean annual soil temperature is 70° F. Kanepuu soils are upslope from Lahaina soils.

These soils are used for wildlife habitat and pasture. The natural vegetation consists of dallisgrass, uhaloa, lantana, and molassesgrass.

Kanepuu silty clay, 3 to 7 percent slopes (KhB).—This soil occurs on the northern plateau of Lanai. The slopes are smooth. Included in mapping were a few small areas of Blown-out land.

In a representative profile the surface layer is dark reddish-brown silty clay about 11 inches thick. The subsoil, 40 to more than 50 inches thick, is silty clay that has subangular blocky structure. It is dark reddish brown in the upper part and dark brown in the lower part. The substratum is soft, weathered rock. The soil is slightly acid to neutral throughout the profile.

Permeability is moderate, and runoff is slow. The hazard of water erosion is slight, but the hazard of wind erosion is severe in areas exposed to trade winds. The available water capacity is about 1.4 inches per foot of soil. In places roots penetrate to a depth of 5 feet or more.

Representative profile: Island of Lanai, lat. 20°51′54″ N. and long. 156°54′54″ W.

A11—0 to 3 inches, dark reddish-brown (5YR 3/3) silty clay, reddish brown (5YR 4/3) when dry; strong, very fine to medium, granular structure; hard, firm, sticky and plastic; many interstitial pores; many roots; violent effervescence with hydrogen peroxide; slightly acid; clear, smooth boundary. 3 to 4 inches thick.

A12—3 to 11 inches, dark reddish-brown (5YR 3/3), moist and dry, silty clay; weak, fine and medium, subangular blocky structure; hard, friable, sticky and plastic; many roots; common, very fine, tubular pores; moderately high bulk density; violent effervescence with hydrogen peroxide; slightly acid; clear, smooth boundary. 6 to 8 inches thick.

B1—11 to 15 inches, dark reddish-brown (5YR 3/2) silty clay, reddish brown (5YR 4/3) when dry; moderate, very fine and fine, subangular blocky structure; hard, friable, sticky and plastic; few roots; many, very fine, tubular pores; moderately high bulk density; slight effervescence with hydrogen peroxide; neutral; clear, smooth boundary. 3 to 4 inches thick.

B21—15 to 21 inches, dark reddish-brown (5YR 3/3) silty clay, reddish brown (5YR 4/3) when dry; strong, very fine and fine, subangular blocky structure; hard, friable, very sticky and very plastic; few roots; many, very fine and fine, tubular pores; ped surfaces have a metallic sheen; compact in place; no effervescence with hydrogen peroxide; neutral; gradual, wavy boundary. 5 to 6 inches thick.

B22t—21 to 36 inches, dark reddish-brown (5YR 3/3), moist and dry, silty clay; strong, very fine and fine, angular and subangular blocky structure; very hard, firm, sticky and very plastic; few roots; many, very fine, tubular pores; ped surfaces have almost continuous red clay films; ped surfaces have metallic sheen; many, hard, earthy lumps that persist when rubbed; compact in place; slightly acid; gradual, wavy boundary. 15 to 19 inches thick.

B23t—36 to 53 inches, dark-brown (7.5YR 3/4), moist and dry, silty clay; strong, coarse, subangular blocky structure breaking to strong, very fine and fine, angular blocky and subangular blocky; hard, firm, sticky and plastic; few roots; many, very fine, tubular pores; almost continuous red clay films on ped surfaces; many, hard, earthy lumps that persist when rubbed; compact in place but less so than the B22t horizon; slightly acid; gradual, wavy boundary. 15 to 20 inches thick.

B24t—53 to 61 inches, dark-brown (7.5YR 3/2), moist and dry, silty clay; moderate, very fine and fine, subangular blocky structure; hard, firm, sticky and plastic; few roots; many, very fine, tubular pores; common red clay films on ped surfaces; firm in place; few strongly weathered rock fragments; slightly acid.

The depth to bedrock is more than 5 feet. In most years the soil is dry in some places to a depth of 10 to 40 inches for more than 90 cumulative days. The A horizon is 2 to 3 in chroma when moist. The A and B1 horizons have a moderate concentration of heavy minerals. The B horizon ranges from 5YR to 7.5YR in hue, from 3 to 4 in value when moist, and from 2 to 4 in chroma when moist and 3 to 4 when dry.

This soil is used for pasture and wildlife habitat. (Capability classification IIe if irrigated, IIIc if nonirrigated; pasture group 3)

Kanepuu silty clay, 3 to 7 percent slopes, eroded (KhB2).—This soil has a profile like that of Kanepuu silty clay, 3 to 7 percent slopes, except that it consists essentially of subsoil; the surface layer has been removed by wind erosion. Much of the area is relatively smooth and is barren. Some areas have a hummocky topography caused by blowouts and deposition of windblown material. Runoff is medium. The hazard of water erosion is moderate, and the hazard of wind erosion is severe. Included in mapping were small areas that are not eroded or are only slightly eroded.

This soil is used for wildlife habitat and pasture. (Capability classification IIe if irrigated, IIIc if nonirrigated; pasture group 3)

Kanepuu silty clay, 7 to 15 percent slopes (KhC).—On this soil, runoff is slow to medium. The hazard of water erosion is slight to moderate, but the hazard of wind erosion is severe in areas exposed to the trade winds. Workability is slightly difficult because of the slope.

This soil is used for pasture and wildlife habitat. (Capability classification IIIe, irrigated or nonirrigated; pasture group 3)

Kanepuu silty clay, 7 to 15 percent slopes, eroded (KhC2).—This soil has a profile like that of Kanepuu silty clay, 3 to 7 percent slopes, except that the surface layer has been removed by wind erosion. Runoff is rapid, and the hazard of wind and water erosion is severe. Most of the area has a relatively smooth surface, but some areas have a hummocky topography caused by blowouts and deposition of windblown material. Much of the area is barren. Included in mapping were severely eroded areas where small gullies are common.

This soil is used for wildlife habitat and pasture. Vegetation is difficult to establish, because of drying winds and low rainfall. Capability classification IIIe if irrigated, IVe if nonirrigated; pasture group 3)

Kapaa Series

This series consists of well-drained soils on uplands on the islands of Kauai and Oahu. These soils developed in material weathered from basic igneous rock. They are gently sloping to extremely steep. Elevations range from 200 to 800 feet. The annual rainfall amounts to 80 to 120 inches. The mean annual soil temperature is 71° F. Kapaa soils are geographically associated with Halii and Puhi soils on Kauai and with Paaloa soils on Oahu.

These soils are used for sugarcane, pasture, pineapple, orchard and truck crops, woodland, wildlife habitat, and water supply. The natural vegetation consists of ricegrass, hilograss, yellow foxtail, Christmas berry, false staghornfern, guava, rhodomyrtus, melastoma, and associated plants.

Kapaa silty clay, 3 to 8 percent slopes (KkB).—This soil is on broad ridges in the uplands. Included in mapping were about 300 acres on Kauai, south of Puu Kolo peak and southwest of Knudsen gap. This soil formed in volcanic ejecta. The surface layer and the upper part of the subsoil contain less gibbsite than is typical.

In a representative profile the surface layer is dark yellowish-brown silty clay about 14 inches thick. The subsoil, about 46 inches thick, is yellowish-red and reddish-brown silty clay that has subangular blocky structure. The substratum is soft, weathered rock. The surface layer is strongly acid. The subsoil is medium acid to very strongly acid.

Permeability is moderately rapid. Runoff is slow, and the erosion hazard is slight. In places roots penetrate to a depth of 5 feet or more.

Representative profile: Island of Kauai, lat. 22°2′42″ N. and long. 159°23′31″ W.

Ap—0 to 14 inches, dark yellowish-brown (10YR 4/4) silty clay, dark yellowish brown (10YR 4/4) when dry; weak, fine, granular structure; slightly hard, friable, sticky and plastic; abundant roots; matted at bottom

of horizon; many pores; about 10 percent of volume made up of yellowish-red (5YR 4/6) material turned up by plowing; sand-size soil aggregates, resistant to crushing, that break down with prolonged rubbing; slight reaction to hydrogen peroxide; a few angular gibbsite aggregates, up to 1 inch across, on surface and mixed in soil; strongly acid; abrupt, smooth boundary. 12 to 14 inches thick.

B21—14 to 22 inches, yellowish-red (5YR 4/6) silty clay, reddish brown (5YR 4/4) when dry; weak, medium, subangular blocky structure; hard, friable, sticky and plastic; very few roots; many fine and medium pores; thin coatings in pores, patchy coatings on ped faces; coatings look like clay films; about 5 percent weathered pebbles impregnated with gibbsite; medium acid; clear, smooth boundary. 4 to 8 inches thick.

B22—22 to 31 inches, yellowish-red (5YR 4/6) light clay loam, strong brown (7.5YR 4/6) when dry; weak, medium and fine, subangular blocky structure; hard, friable, sticky and plastic, and weakly smeary; very few roots; many, medium, fine and very fine pores; gelatinlike coatings in pores, patchy on ped faces; about 25 percent soft, weathered pebbles impregnated with gibbsite; medium acid; clear, smooth boundary. 8 to 10 inches thick.

B23—31 to 38 inches, reddish-brown (5YR 4/4) silty clay, strong brown (7.5YR 5/6) when dry; weak, medium and fine, subangular blocky structure; slightly hard, friable, sticky and plastic; very few roots; many, medium, fine and very fine pores; gelatinlike coatings in pores, patchy on ped faces; about 10 percent soft, weathered pebbles impregnated with gibbsite; discontinuous bands and lenses of yellowish material that is presumed to be gibbsite; medium acid; clear, smooth boundary. 6 to 12 inches thick.

B24—38 to 45 inches, yellowish-red (5YR 4/6) silty clay, yellowish red (5YR 5/6) when dry; weak, medium and fine, subangular blocky structure; hard, friable, slightly sticky and plastic; very few roots; many, medium, fine and very fine pores; about 30 percent soft, weathered pebbles impregnated with gibbsite, also impregnated with lesser amounts of other whitish material that looks like halloysite; some soft and hard, reddish-yellow (7.5YR 6/8) material; medium acid; clear, wavy boundary. 6 to 15 inches thick.

B25—45 to 60 inches, yellowish-red (5YR 4/8) light clay loam, strong brown (7.5YR 5/6) when dry; massive; hard, friable, sticky and plastic, and weakly smeary; no roots; many, medium, fine and very fine pores; 25 to 40 percent soft, weathered pebbles impregnated with gibbsite and lesser amounts of whitish material that looks like halloysite; vertical bands of red (2.5YR 4/6) that has 1/16-inch edge of dark reddish brown (2.5YR 3/4); very strongly acid.

The A horizon ranges from 7.5YR to 2.5Y in hue, from 2 to 4 in chroma, and from 2 to 4 in value. The B horizon ranges from 5YR to 7.5YR in hue, from 3 to 8 in chroma, and from 3 to 4 in value. In places the B horizon is light clay loam and silty clay loam. In some places hard, angular, weathered rock fragments and concretions occur in any horizon and range from few to many.

This soil is used for sugarcane, pasture, pineapple, orchards, truck crops, wildlife habitat, and woodland. (Capability classification IIIs, nonirrigated; sugarcane group 2; pineapple group 7; pasture group 10; woodland group 9)

Kapaa silty clay, 8 to 15 percent slopes (KkC).—On this soil, runoff is slow to medium and the erosion hazard is slight to moderate. Included in mapping were 202 acres on Kauai, south of Puu Kolo peak and southwest of Knudsen gap. This soil formed in volcanic ejecta. The surface layer and the upper part of the subsoil contain less gibbsite than is typical.

This soil is used for sugarcane, pasture, pineapple, orchards, wildlife habitat, and woodland. (Capability classification IIIe, nonirrigated; sugarcane group 2; pineapple group 8; pasture group 10; woodland group 9)

Kapaa silty clay, 15 to 25 percent slopes (KkD).—On this soil, runoff is medium and the erosion hazard is moderate.

Included in mapping was a small area on Kauai, south of Puu Kolo peak and southwest of Knudsen gap. This soil formed in volcanic ejecta. The surface layer and the upper part of the subsoil contain less gibbsite than is typical.

This soil is used for sugarcane, pineapple, pasture, orchards, wildlife habitat, and woodland. (Capability classification IVe, nonirrigated; sugarcane group 2; pineapple group 8; pasture group 10; woodland group 9)

Kapaa silty clay, 25 to 40 percent slopes (KkE).—On this soil, runoff is rapid and the erosion hazard is moderate to severe. Part of the surface layer has been removed by erosion.

This soil is used for pasture, wildlife habitat, and woodland. (Capability classification VIe, nonirrigated; pasture group 10; woodland group 9)

Kapaa silty clay, 40 to 100 percent slopes (KlG).—On this soil, runoff is very rapid and the erosion hazard is very severe. Most of the surface layer has been removed by erosion.

Included in mapping were small, narrow areas on ridgetops that have an ironstone sheet, 1/8 to 1/2 inch thick, about 10 to 18 inches below the surface. These soils are mottled and in many places have a thin gray layer, 1/2 inch to 3 inches thick, below the surface layer. Rock outcrop, Stony steep land, Rough broken land, eroded spots, and Rough mountainous land make up about 25 percent of the acreage.

This soil is used for water supply, wildlife habitat, and woodland. (Capability classification VIIe, nonirrigated; pasture group 10; woodland group 14)

Kapuhikani Series

This series consists of well-drained, extremely stony soils on uplands on the leeward slopes of West Molokai. These soils are underlain by bedrock at a depth of about 24 inches. They developed in material derived from olivine basalt. They are gently sloping and moderately sloping. Elevations range from nearly sea level to 500 feet. The annual rainfall amounts to 10 to 15 inches. Most of the rain occurs during storms from November to April. The mean annual soil temperature is 75° F. Kapuhikani soils are geographically associated with Holomua and Molokai soils.

These soils are used for wildlife habitat and pasture. The natural vegetation consists of kiawe, zinnia, ilima, and uhaloa.

Kapuhikani extremely stony clay, 3 to 15 percent slopes (KKTC).—This soil contains many stones on the surface and throughout the profile. Included in mapping were areas of Very stony land and Very stony land, eroded. Each of these included land types makes up about 10 percent of the acreage.

In a representative profile the surface and subsurface layers are dark-brown, very sticky and very plastic clay

about 20 inches thick. The clay shrinks and cracks widely when dry and swells when wet. The substratum consists of about 7 inches of yellowish-brown and pale-brown, highly weathered rock that has an accumulation of calcium carbonate. Bedrock occurs at a depth of about 27 inches.

Permeability is slow. Runoff is slow to medium, and the erosion hazard is slight to moderate. Roots are affected by the bedrock. Tillage for pasture or other uses is impractical because of the abundant stones and shallowness. The shrink-swell potential is very high.

Representative profile: Island of Molokai, lat. 21°06′18″ N. and long. 157°18′34″ W.

A1—0 to 4 inches, dark-brown (10YR 3/3), moist or dry, extremely stony clay; strong, very fine and fine, granular structure; hard, firm, very sticky and very plastic; few roots; many interstitial pores; violent effervescence with hydrogen peroxide; slight effervescence with hydrochloric acid, confined mainly to few calcium carbonate fragments less than 1 millimeter in diameter; mildly alkaline; gradual, smooth boundary. 2 to 4 inches thick.

AC—4 to 20 inches, dark-brown (10YR 3/3), moist or dry, clay; weak, coarse, prismatic structure breaking to weak, coarse, subangular and angular blocky; very hard, very firm, very sticky and very plastic; few roots; many, fine, tubular pores; many olivine crystals less than 1 millimeter in diameter; common pressure cutans and slickensides; common calcium carbonate fragments up to 1 inch long; very firm in place; violent effervescence with hydrogen peroxide; moderate effervescence with hydrochloric acid, confined mainly to calcium carbonate fragments; mildly alkaline; gradual, smooth boundary. 12 to 18 inches thick.

Cca—20 to 27 inches, variegated yellowish-brown (10YR 5/6) and very pale brown (10YR 8/3), highly weathered olivine basalt that has calcium carbonate accumulation; violent effervescence with hydrochloric acid; moderately alkaline. 3 to 9 inches thick.

R—27 inches, hard olivine basalt.

This soil is 20 to 31 inches deep over hard olivine basalt. Stoniness ranges from very stony to extremely stony. In many places the stones cover most of the surface layer. The content of olivine crystals ranges from few to many throughout the profile. In most years the soil is dry more than 6 months. The A horizon is typically 10YR in hue, but in places the hue is 7.5YR. This horizon ranges from 2 to 3 in value and chroma. Slickensides in the AC horizon range from common to many and are weakly to strongly grooved.

This soil is used for wildlife habitat and pasture. (Capability classification VIIs, nonirrigated; pasture group 1)

Kaupo Series

This series consists of well-drained soils on alluvial fans on the island of Maui. These soils developed in a mixture of volcanic ash and alluvium derived from basic igneous rock. They are gently sloping to moderately steep. Elevations range from nearly sea level to 1,000 feet. The annual rainfall amounts to 40 to 60 inches. The mean annual soil temperature is 75° F. Kaupo soils are geographically associated with Makaalae and Waiakoa soils.

These soils are used for pasture and wildlife habitat. The natural vegetation consists of apple-of-Sodom, bermudagrass, castorbean, guineagrass, kikuyugrass, koa haole, lantana, and oi.

Kaupo very stony silty clay loam, 3 to 25 percent slopes (KLUD).—This soil is on alluvial fans. Included in mapping were small areas of very stony silty clay. Also included were small areas from which stones have been removed.

In a representative profile the surface layer is very dark brown silty clay loam about 6 inches thick. The subsoil, about 13 inches thick, is very dark grayish-brown silty clay loam that has subangular blocky structure. The substratum is very dark grayish-brown very cobbly clay loam and fragmental Aa lava that contains very little soil material in voids. The soil is slightly acid in the surface layer and neutral in the subsoil.

Permeability is moderately rapid. Runoff is slow to medium, and the erosion hazard is slight to moderate. The available water capacity is 1.4 inches per foot in the surface layer and subsoil. In places roots penetrate to a depth of 40 inches.

Representative profile: Island of Molokai, lat. 21°06′18″ N. and long. 157°18′34″ W.

Ap—0 to 6 inches, very dark brown (10YR 2/2) very stony silty clay loam, dark grayish brown (10YR 4/2) when dry; strong, very fine and fine, subangular blocky structure; hard, friable, slightly sticky and slightly plastic; abundant fine and very fine roots; many fine pores; common, very fine, earthy lumps; 30 to 40 percent gravel, cobblestones, and stones; weak effervescence with hydrogen peroxide; slightly acid; clear, wavy boundary. 4 to 8 inches thick.

B2—6 to 19 inches, very dark grayish-brown (10YR 3/2) cobbly silty clay loam, grayish brown (10YR 5/2) when dry; weak, medium, subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; abundant fine and very fine roots; common fine pores; 40 to 50 percent gravel and cobblestones; neutral; clear, wavy boundary. 10 to 15 inches thick.

C1—19 to 27 inches, very dark grayish-brown (10YR 3/2) very cobbly clay loam, dark grayish brown (10YR 4/2) when dry; massive; soft, very friable, slightly sticky and slightly plastic; abundant fine and very fine roots; many fine pores; 60 to 70 percent gravel and cobblestones; neutral; clear, irregular boundary. 6 to 10 inches thick.

IIC2—27 inches, fragmental Aa lava that contains a little soil material in cracks.

The depth to fragmental Aa lava ranges from 20 to 40 inches. The A horizon has a texture of silt loam or silty clay loam. The B horizon is cobbly clay loam or cobbly silty clay loam.

This soil is used for pasture land and wildlife habitat. (Capability classification VIs, nonirrigated; pasture group 3; woodland group 1)

Kaupo extremely stony silty clay, 3 to 25 percent slopes (KLVD).—This soil has a profile like that of Kaupo very stony silty clay loam, 3 to 25 percent slopes, except that the surface layer is silty clay and the soil is extremely stony.

This soil is used for pasture and wildlife habitat. (Capability classification VIs, nonirrigated; pasture group 3; woodland group 1)

Kawaihapai Series

This series consists of well-drained soils in drainageways and on alluvial fans on the coastal plains on the islands of Oahu and Molokai. These soils formed in alluvium derived from basic igneous rock in humid uplands.

They are nearly level to moderately sloping. Elevations range from nearly sea level to 300 feet. The annual rainfall amounts to 30 to 50 inches. The mean annual soil temperature is 73° F. Kawaihapai soils are geographically associated with Haleiwa, Waialua, and Jaucas soils.

These soils are used for sugarcane, truck crops, and pasture. The natural vegetation consists of kiawe, koa haole, lantana, and bermudagrass.

Kawaihapai clay loam, 0 to 2 percent slopes (KlA).—This soil occupies smooth slopes. Included in mapping were small areas where the slope is 3 to 7 percent and the texture is silty clay. Also included were small areas of poorly drained soils and small areas of Jaucas soils. At the mouth of the Pelekunu and Wailau Valleys on Molokai, this soil receives more rainfall than is typical of the series. The natural vegetation consists of guava, honohono, kukui, and hala.

In a representative profile the surface layer is dark-brown clay loam about 22 inches thick. The next layer is dark-brown stratified sandy loam 32 inches thick. The substratum is stony and gravelly. The soil is neutral in reaction throughout the profile.

Permeability is moderate. Runoff is slow, and the erosion hazard is no more than slight. The available water capacity is about 1.8 inches per foot in the surface layer and about 1.6 inches per foot in the subsoil. In places roots penetrate to a depth of 5 feet or more. In some places this soil is subject to flooding.

Representative profile: Island of Oahu, lat. 21°24′26″ N. and long. 157°59′08″ W.

Ap1—0 to 12 inches, dark-brown (7.5YR 4/2) clay loam, very dark brown (7.5YR 2/2) when moist; weak, medium and coarse, granular structure; hard, firm, sticky and plastic; abundant fine and very fine roots; common, fine, tubular and interstitial pores; 5 percent rounded basaltic gravel; moderate effervescence with hydrogen peroxide; neutral; gradual, smooth boundary. 6 to 12 inches thick.

Ap2—12 to 22 inches, dark-brown (7.5YR 4/4) clay loam, dark brown (7.5YR 3/2) when moist; weak, medium and coarse, subangular blocky structure; hard, firm, sticky and plastic; abundant roots; common, fine and very fine, tubular pores; 5 percent rounded basaltic gravel; moderate effervescence with hydrogen peroxide; neutral; clear, smooth boundary. 6 to 10 inches thick.

IIC1—22 to 32 inches, dark-brown (7.5YR 4/4) sandy loam; massive; slightly hard, very friable, slightly sticky and slightly plastic; abundant fine and very fine roots; common, fine, tubular pores; 5 percent rounded basaltic gravel; moderate effervescence with hydrogen peroxide; neutral; gradual, smooth boundary. 8 to 10 inches thick.

IIIC2—32 to 54 inches, dark-brown (7.5YR 4/4) sandy loam; massive; slightly hard, very friable, slightly sticky and slightly plastic; plentiful very fine and fine roots; common, fine, tubular pores; stratified bands of sand, silt, and gravel; moderate effervescence with hydrogen peroxide; neutral.

The A horizon ranges from 5YR to 10YR in hue, from 2 to 3 in value when moist, and from 2 to 3 in chroma. It ranges from clay loam to silty clay loam in texture and in places is gravelly or stony. The C horizon is variable within short distances and is strongly stratified. It ranges from sandy loam to silty clay loam in texture.

This soil is used for sugarcane, truck crops, pasture, and orchards. (Capability classification I if irrigated, IIc if nonirrigated; sugarcane group 1; pasture group 3; woodland group 1)

Kawaihapai clay loam, 2 to 6 percent slopes (KlB).—On this soil, runoff is slow and the erosion hazard is slight. This soil is used for sugarcane, truck crops, and pasture. (Capability classification IIe, irrigated or nonirrigated; sugarcane group 1; pasture group 3; woodland group 1)

Kawaihapai clay loam, 6 to 15 percent slopes (KlC).—On this soil, runoff is slow to medium and the erosion hazard is slight to moderate. Workability is slightly difficult because of the slope. Included in mapping were small, very stony areas in drainageways.

This soil is used for sugarcane and pasture. (Capability classification IIIe, irrigated or nonirrigated; sugarcane group 1; pasture group 3; woodland group 1)

Kawaihapai stony clay loam, 0 to 2 percent slopes (KlaA).—This soil is similar to Kawaihapai clay loam, 0 to 2 percent slopes, except that there are enough stones to hinder, but not prevent, cultivation. Workability is slightly difficult because of stoniness.

This soil is used for sugarcane, truck crops, and pasture. (Capability classification IIs, irrigated or nonirrigated; sugarcane group 1; pasture group 3; woodland group 1)

Kawaihapai stony clay loam, 2 to 6 percent slopes (KlaB).—This soil is similar to Kawaihapai clay loam, 0 to 2 percent slopes, except that there are enough stones to hinder, but not prevent, cultivation. Runoff is slow, and the erosion hazard is slight.

Included in mapping were small areas of silty clay and small areas where the slope is 6 to 15 percent.

This soil is used for sugarcane, truck crops, and pasture. (Capability classification IIe, irrigated or nonirrigated; sugarcane group 1; pasture group 3; woodland group 1)

Kawaihapai very stony clay loam, 0 to 15 percent slopes (KlbC).—This soil is similar to Kawaihapai clay loam, 0 to 2 percent slopes, except that it has enough stones to prevent cultivation. Runoff is medium, and the erosion hazard is moderate. Workability is impractical unless the stones are removed.

This soil is used for pasture. (Capability classification VIs, nonirrigated; pasture group 3; woodland group 1)

Kawaihapai silty clay loam, 2 to 7 percent slopes (KlcB).—This soil occurs in narrow drainageways near Kalae, Molokai. In places the slope is as much as 12 percent near the walls of gulches.

This soil differs from the typical Kawaihapai soil in the following respects: It occurs at higher elevations (750 to 1,750 feet); the annual rainfall amounts to 40 to 55 inches; and the soil is strongly acid in the surface layer and medium acid in the subsoil.

This soil is used for pasture. Nearly all areas are in kikuyugrass and kaimiclover. The soil receives runoff from higher areas; and, consequently, lack of moisture is less limiting than on the surrounding soils. (Capability classification IIe, irrigated or nonirrigated; sugarcane group 1; pasture group 3; woodland group 1)

Keaau Series

This series consists of poorly drained soils on coastal plains on the island of Oahu. These soils developed in alluvium deposited over reef limestone or consolidated coral sand. They are nearly level and gently sloping. Elevations range from 5 to 40 feet. The annual rainfall

amounts to 20 to 35 inches. Most of the rainfall occurs between November and April. The mean annual soil temperature is 73° F. Keaau soils are geographically associated with Kaloko, Mokuleia, and Pearl Harbor soils.

These soils are used for sugarcane and pasture. The natural vegetation consists of kiawe, bermudagrass, bristly foxtail, and fingergrass.

Keaau clay, 0 to 2 percent slopes (KmA).—This soil occurs on lowlands on the coastal plains. Included in mapping were small areas of coral sand and dark-colored, sticky and plastic clay on fans above the Keaau soils.

In a representative profile the surface layer is very dark grayish-brown clay about 15 inches thick. The subsoil, about 19 inches thick, is very dark grayish-brown and dark-brown, mottled clay that has subangular and angular blocky structure. The substratum is white to very pale brown reef limestone or consolidated coral sand. The soil is mildly alkaline in the surface layer and subsoil and moderately alkaline in the substratum. The water table is at a depth of 1½ to 3 feet.

Permeability is slow. Runoff is slow, and the erosion hazard is no more than slight. The available water capacity is about 1.5 inches per foot of soil. Roots are restricted by the consolidated coral sand, reef limestone, and water table. Workability is difficult because the soil is very sticky and very plastic. The shrink-swell potential is high.

Representative profile: Island of Oahu, lat. 21°34′44″ N. and long. 158°09′13″ W.

Ap—0 to 15 inches, very dark grayish-brown (10YR 3/2) clay, very dark grayish brown (10YR 4/2) when dry; moderate, fine and very fine, granular structure; hard, firm, very sticky and very plastic; abundant very fine and fine roots; common medium, fine, and very fine interstitial pores; common wormholes and worm casts; many coral sand grains; few fine fragments of weathered basalt; few, fine, faint, brown mottles; slight effervescence with hydrogen peroxide; slight effervescence with hydrochloric acid; mildly alkaline; clear, wavy boundary. 10 to 15 inches thick.

B21—15 to 26 inches, very dark grayish-brown (10YR 3/2) silty clay; moderate, fine and medium, subangular and angular blocky structure; hard, firm, sticky and plastic; plentiful fine and very fine roots; many, very fine, tubular pores; few coral sand grains; few highly weathered basalt fragments; continuous pressure cutans; few, fine, faint, brown mottles; slight effervescence with hydrogen peroxide; slight effervescence with hydrochloric acid on sand grains but none on soil mass; mildly alkaline; clear, wavy boundary. 8 to 12 inches thick.

B22—26 to 34 inches, dark-brown (7.5YR 3/2 moist, 7.5YR 4/2 dry) clay; strong, very fine and fine, subangular and angular blocky structure; extremely hard, firm, very sticky and very plastic; plentiful fine and very fine roots; common, very fine and fine, tubular pores; many, fine, distinct, yellowish-red (5YR 4/6 dry)) mottles in pores and on ped faces; continuous pressure cutans; few, fine, highly weathered basalt fragments; strong effervescence with hydrogen peroxide; mildly alkaline; abrupt, smooth boundary. 6 to 8 inches thick.

IIC1m—34 to 39 inches, variegated pattern of white to light brownish-gray (10YR 8/2 to 10YR 6/2) fine shell fragments and coral sand; very hard and consolidated; no roots; few fine pores; slight effervescence with hydrogen peroxide; violent effervescence with hydrochloric acid; moderately alkaline; abrupt, wavy boundary. 3 to 10 inches thick.

IIIC2—39 to 57 inches, very pale brown (10YR 7/3), moist and dry, coral sand; single grain; water table in this layer; moderately alkaline.

The depth to consolidated coral sand or reef limestone ranges from 24 to 35 inches. The A horizon ranges from 1 to 2 in chroma. The B horizon ranges from silty clay to clay in texture and from 10YR to 7.5YR in hue. The degree of mottling is variable and ranges from faint to distinct throughout the B horizon.

This soil is used for sugarcane and pasture. (Capability classification IIIw if irrigated, Vw if nonirrigated; sugarcane group 3; pasture group 7; woodland group 4)

Keaau stony clay, 2 to 6 percent slopes (KmaB).—This soil has a profile like that of Keaau clay, 0 to 2 percent slopes, except that there are sufficient stones to hinder machine cultivation. Runoff is slow, and the erosion hazard is slight.

This soil is used for sugarcane and pasture. (Capability classification IIIw if irrigated, Vw if nonirrigated; sugarcane group 3; pasture group 7; woodland group 4)

Keaau clay, saline, 0 to 2 percent slopes (KmbA).—This soil has a profile like that of Keaau clay, 0 to 2 percent slopes, except that it is strongly affected by salts. It occurs in depressions adjacent to the ocean or in pockets within the limestone areas where seepage water evaporates. The surface structure is platy or vesicular. The dominant vegetation is pickleweed; some areas are barren.

Under natural conditions, this soil is either idle or is used for pasture. Many areas, however, are being drained and filled for use for sugarcane, industrial sites, homesites, and parks. New sugarcane areas are made by draining and filling with waste from sugarcane mills. (Capability classification VIw, nonirrigated; pasture group 7; woodland group 4)

Keahua Series

This series consists of well-drained soils on uplands on the island of Maui. These soils developed in material weathered from basic igneous rock. They are gently sloping to moderately steep. Elevations range from 600 to 1,500 feet. The annual rainfall amounts to 15 to 25 inches. The mean annual soil temperature is 73° F. Keahua soils are geographically associated with Haliimaile, Molokai, Paia, and Waiakoa soils.

These soils are used for sugarcane, pasture, and wildlife habitat. Small acreages are used for pineapple, truck crops, and homesites. The natural vegetation consists of buffelgrass, feather fingergrass, ilima, kiawe, lantana, pitted beardgrass, and uhaloa.

Keahua silty clay loam, 3 to 7 percent slopes (KnB).—This soil is on uplands. Included in mapping were small areas of Haliimaile and Molokai soils, and small areas that are 20 to 40 inches deep over soft, weathered basic igneous rock. Also included were small areas of silty clay and some areas that are nearly level.

In a representative profile the surface layer is dark reddish-brown silty clay loam about 10 inches thick. The subsoil, about 50 inches thick, is dark reddish-brown silty clay loam and very dark gray clay loam that has subangular blocky structure. The substratum is dominantly soft, weathered basic igneous rock. The soil is

slightly acid in the surface layer and slightly acid to neutral in the subsoil.

Permeability is moderate. Runoff is slow, and the erosion hazard is slight. The available water capacity is about 1.3 inches per foot of soil. In places roots penetrate to a depth of 4 feet or more.

Representative profile: Island of Maui, lat. 20°49′56″ N. and long. 156°23′08″ W.

Ap1—0 to 5 inches, dark reddish-brown (5YR 3/2) silty clay loam, dark reddish brown (5YR 3/3) when dry; weak, very fine, granular structure and weak, very fine and fine, subangular blocky; common clods up to 2 inches in diameter; soft friable, slightly sticky and plastic; plentiful roots; many very fine pores; common sand-size aggregates that are resistant to crushing; common, fine, black concretions; violent effervescence with hydrogen peroxide; slightly acid; gradual, wavy boundary. 3 to 6 inches thick.

Ap2—5 to 10 inches, dark reddish-brown (5YR 3/3) silty clay loam, dark reddish brown (5YR 3/4) when dry; weak, coarse and medium, subangular blocky structure; common clods up to 2 inches in diameter; soft, friable, slightly sticky and plastic; abundant roots; many very fine pores; common sand-size aggregates that are resistant to crushing; common, fine, black concretions; violent effervescence with hydrogen peroxide; slightly acid; clear, wavy boundary. 4 to 6 inches thick.

B1—10 to 15 inches, dark reddish-brown (5YR 3/3) silty clay loam, dark reddish brown (5YR 3/4) when dry; weak, coarse and medium, subangular blocky structure; soft, very friable, slightly sticky and plastic; plentiful roots; many fine pores; few sand-size aggregates that are resistant to crushing; few, fine, black concretions; strong effervescence with hydrogen peroxide; slightly acid; gradual, wavy boundary. 4 to 7 inches thick.

B21—15 to 24 inches, dark reddish-brown (5YR 3/3) silty clay loam, dark reddish brown (5YR 3/4) when dry; moderate, medium and fine, subangular blocky structure; slightly hard, friable, slightly sticky and plastic; few roots; many fine and medium pores; firm in place; few sand-size aggregates that are resistant to crushing; few, fine, black concretions; strong effervescence with hydrogen peroxide; slightly acid; clear, wavy boundary. 8 to 11 inches thick.

B22—24 to 33 inches, dark reddish-brown (5YR 3/3) silty clay loam, dark reddish brown (5YR 3/4) when dry; moderate, fine and very fine, subangular blocky structure; slightly hard, firm, slightly sticky and plastic; few roots; common fine and medium pores; nearly continuous pressure cutans; firm in place; few, fine, black concretions; slight effervescence with hydrogen peroxide; slightly acid; clear, wavy boundary. 8 to 11 inches thick.

IIB3—33 to 62 inches, very dark gray (10YR 3/1) clay loam, dark gray (10YR 4/1) when dry; moderate, fine and very fine, subangular blocky structure; hard, firm, slightly sticky and plastic; few fine roots; common fine pores; nearly continuous pressure cutans; firm in place; many sand-size aggregates that are resistant to crushing; neutral; gradual, wavy boundary. 27 to 32 inches thick.

IIC—62 to 70 inches, very dark gray (10YR 3/1) clay loam, dark gray (10YR 4/1) when dry; moderate, fine and very fine, subangular blocky structure; hard, firm, slightly sticky and plastic; few fine roots; common fine pores; nearly continuous pressure cutans; firm in place; many sand-size aggregates that are resistant to crushing; contains 60 to 70 percent highly weathered rock fragments.

The solum is more than 60 inches thick. The A horizon ranges from 5YR to 7.5YR in hue; from 2 to 3 in value when moist or dry; and from 2 to 3 in chroma when moist and 2 to 4 when dry. The B horizon ranges from 2 to 3 in value when moist and 3 to 4 when dry, and from 1 to 4 in chroma when moist or dry.

This soil is used for sugarcane. Small areas are used for pineapple, pasture, and truck crops. (Capability classification IIe if irrigated, IVc if nonirrigated; sugarcane group 1; pineapple group 2; pasture group 2)

Keahua silty clay loam, 7 to 15 percent slopes (KnC).—On this soil, runoff is slow to medium and the erosion hazard is slight to moderate.

This soil is used for sugarcane and pasture. Small acreages are used for pineapple and truck crops. (Capability classification IIIe if irrigated, IVe if nonirrigated; sugarcane group 1; pineapple group 3; pasture group 2)

Keahua cobbly silty clay loam, 3 to 7 percent slopes (KnaB).—This soil has a profile like that of Keahua silty clay loam, 3 to 7 percent slopes, except that it is cobbly on the surface. Included in mapping were small areas that are 20 to 40 inches deep over soft, weathered basic igneous rock. Also included were small areas of silty clay.

This soil is used for sugarcane. A few acres are used for truck crops. (Capability classification IIe if irrigated, IVs if nonirrigated; sugarcane group 1; pasture group 2)

Keahua cobbly silty clay loam, 7 to 15 percent slopes (KnaC).—On this soil, runoff is slow to medium and the erosion hazard is slight to moderate. Included in mapping were small areas that are 20 to 40 inches deep over soft, weathered basic igneous rock.

This soil is used for sugarcane and pasture. A few acres are used for truck crops. (Capability classification IIIe if irrigated, IVe if nonirrigated; sugarcane group 1; pasture group 2)

Keahua cobbly silty clay loam, 15 to 25 percent slopes (KnaD).—On this soil, runoff is medium and the erosion hazard is moderate. Included in mapping were small areas that are not cobbly. Also included were a few steep areas.

This soil is used for sugarcane and pasture. (Capability classification IVe, irrigated or nonirrigated; sugarcane group 1; pasture group 2)

Keahua very stony silty clay loam, 7 to 25 percent slopes (KnbD).—This soil has a profile like that of Keahua silty clay loam, 3 to 7 percent slopes, except that stones cover as much as 3 percent of the surface. Runoff is slow to medium, and the erosion hazard is slight to moderate.

Included in mapping were small areas that are 20 to 40 inches deep over soft, weathered basic igneous rock. In a few places stones cover 3 to 15 percent of the surface.

This soil is used for pasture and wildlife habitat. (Capability classification VIs, nonirrigated; pasture group 2)

Keahua silty clay, 7 to 15 percent slopes (KncC).—On this soil, runoff is slow to medium and the erosion hazard is slight to moderate. Included in mapping were small areas that are 20 to 40 inches deep over soft, weathered basic igneous rock.

This soil is used for pineapple, pasture, and homesites. (Capability classification IIIe if irrigated, IVe if nonirrigated; sugarcane group 1; pineapple group 3; pasture group 2)

Keahua cobbly silty clay, 7 to 15 percent slopes (KnhC).—On this soil, runoff is slow to medium and the erosion hazard is slight to moderate. Included in mapping

were small areas that are 20 to 40 inches deep over soft, weathered basic igneous rock.

This soil is used for pasture. Small acreages are used for truck crops. (Capability classification IIIe if irrigated, IVe if nonirrigated; sugarcane group 1; pasture group 2)

Keahua stony silty clay, 7 to 15 percent slopes (KnsC).—On this soil, runoff is slow to medium and the erosion hazard is slight to moderate. Included in mapping were small, moderately steep areas.

This soil is used for pasture and wildlife habitat. (Capability classification IIIe if irrigated, IVe if nonirrigated; sugarcane group 1; pasture group 2)

Kealia Series

This series consists of somewhat poorly drained and poorly drained soils on coastal flats (fig. 6) on the islands of Molokai and Maui. These soils are nearly level. Elevations range from sea level to 10 feet. The annual rainfall amounts to 10 to 25 inches. The mean annual soil temperature is 75° F. Kealia soils are geographically associated with Jaucas, Mala, and Pulehu soils.

These soils are used for wildlife habitat, pasture, and urban development. The natural vegetation consists of salt-tolerant plants, such as pickleweed, Australian saltbush, and kiawe. Kiawe is generally stunted and grows in the better drained areas. Large areas are barren.

Kealia silt loam (KMW).—This soil is poorly drained and has a high content of salt. Ponding occurs in low areas after a heavy rain. When the soil dries, salt crystals accumulate on the surface. The soil has a brackish water table that fluctuates with the tides; the water table is nearer the surface along the shoreline than in inland areas. The slope ranges from 0 to 1 percent.

In a representative profile the surface layer is dark reddish-brown silt loam about 3 inches thick. Below this are stratified layers of silt loam, loam, and fine sandy loam. A brackish water table occurs at a depth of 12 to 40 inches. The subsurface layers are dark reddish brown to dark reddish gray in the upper part and dark grayish brown to black near the zone of the water table. The soil has a high concentration of salts and is moderately alkaline.

Permeability is moderately rapid. Runoff is slow to very slow. The hazard of water erosion is no more than slight, but the hazard of wind erosion is severe when the soil is dry and the surface layer becomes loose and fluffy.

Representative profile: Island of Molokai, lat. 21°06′39″ N. and long. 157°05′01″ W.

A1sa—0 to 3 inches, dark reddish-brown (5YR 3/3), moist and dry, silt loam; moderate, medium and thin, platy structure; hard, friable, slightly sticky and nonplastic; few roots; many very fine, fine, and medium pores; banding of dark-brown (7.5YR 3/2) material that has similar texture and structure; moderately alkaline; clear, wavy boundary. 2 to 4 inches thick.

Figure 6.—Typical view of Kealia silt loam. Poor drainage and saline conditions restrict vegetation to salt-tolerant plants, such as pickleweed. Many areas are barren.

C1sa—3 to 8 inches, dark reddish-brown (5YR 3/3) silt loam, reddish brown (5YR 4/3) when dry; weak, medium and thin, platy structure breaking to weak, medium and fine, subangular blocky; soft, friable, slightly sticky and nonplastic; few roots; few pores; slight effervescence with hydrogen peroxide; slight effervescence with hydrochloric acid; moderately alkaline; clear, wavy boundary. 4 to 6 inches thick.

C2sa—8 to 19 inches, dark reddish-brown (5YR 3/3) loam, reddish brown (5YR 4/3) when dry; massive; soft, very friable, nonsticky and nonplastic; common roots; many interstitial pores; the lower 4 inches has weak, thin, platy structure and contains some black sand between the plates; has a pseudosand appearance under hand lens; few black concretions less than 1 millimeter in size; slight effervescence with hydrogen peroxide; slight effervescence with hydrochloric acid; moderately alkaline; clear, wavy boundary. 10 to 12 inches thick.

C3sa—19 to 27 inches, dark reddish-brown (5YR 3/3) fine sandy loam, reddish brown (5YR 4/3) when dry; weak, fine, subangular blocky structure; slightly hard, friable, slightly sticky and nonplastic; many roots; many fine pores; few black concretions less than 1 millimeter in size; slight effervescence with hydrogen peroxide or hydrochloric acid; moderately alkaline; abrupt, wavy boundary. 4 to 9 inches thick.

C4sa—27 to 34 inches, black (10YR 2/1) fine sandy loam, dark gray (10YR 4/1) when dry; single grain; loose, nonsticky and nonplastic; few roots; common pieces of weathered coral up to 2 inches in diameter; slight effervescence with hydrochloric acid; mildly alkaline; clear, wavy boundary. 3 to 8 inches thick.

C5sa—34 to 63 inches, black (10YR 2/1) silt loam, dark gray (10YR 4/1) when dry; massive; hard, very friable, slightly sticky and slightly plastic; common pieces of weathered coral up to 2 inches in diameter; water table begins at a depth of 35 inches; slight effervescence with hydrochloric acid; mildly alkaline.

The A horizon has platy structure in places or it is loose and fluffy. It ranges from silt loam to silty clay loam in texture. The depth to the water table ranges from 12 to 40 inches.

This soil is used for wildlife habitat and pasture, but it has low grazing value. It is not used for crops, because of poor drainage and high salt content. Small areas are used for urban development. (Capability classification VIIw, nonirrigated; pasture group 1)

Keawakapu Series

This series consists of well-drained, extremely stony soils on uplands on the island of Maui. These soils developed in volcanic ash. They are gently sloping to moderately steep. Elevations range from 100 to 800 feet. The annual rainfall amounts to 10 to 20 inches. Most of the rainfall occurs in fall and winter. The mean annual soil temperature is 76° F. Keawakapu soils are geographically associated with Kamaole, Makena, and Oanapuka soils.

These soils are used for pasture and wildlife habitat. The natural vegetation consists of feather fingergrass, ilima, kiawe, uhaloa, and zinnia.

Keawakapu extremely stony silty clay loam, 3 to 25 percent slopes (KNXD).—This soil is on low uplands. Included in mapping were small areas of Kamaole and Oanapuka soils.

In a representative profile the surface layer, about 2 inches thick, is dark reddish-brown extremely stony silt loam that has platy structure. The subsoil, about 16 inches thick, is dark reddish-brown silty clay loam and silty clay that has prismatic and subangular blocky structure. The substratum is fragmental Aa lava that has a little soil material in the voids. The soil is neutral in the surface layer and subsoil.

Permeability is moderate. Runoff is slow to medium, and the erosion hazard is slight to moderate. The available water capacity is about 1.5 inches per foot of soil. In places roots penetrate to a depth of 30 inches.

Representative profile: Island of Maui, lat. 20°48′12″ N. and long. 156°25′58″ W.

A1—0 to 2 inches, dark reddish-brown (5YR 3/3) extremely stony silt loam, reddish brown (5YR 4/4) when dry; moderate, medium and thick, platy structure; soft, very friable, slightly sticky and slightly plastic; plentiful fine roots; common fine and very fine pores; has gritty feel; few, fine, black concretions; 15 to 30 percent stones; delayed strong effervescence with hydrogen peroxide; neutral; clear, wavy boundary. 1 to 4 inches thick.

B21—2 to 9 inches, dark reddish-brown (5YR 3/3) very stony silty clay loam, dark reddish brown (5YR 3/4) when dry; weak, coarse, prismatic structure; soft, friable, sticky and plastic; plentiful fine roots; common fine pores; few, hard, sand-size aggregates that are resistant to crushing; few, fine, black concretions; 15 to 30 percent stones; strong effervescence with hydrogen peroxide; neutral; gradual, wavy boundary. 5 to 10 inches thick.

B22—9 to 18 inches, dark reddish-brown (5YR 3/3) silty clay, dark reddish brown (5YR 3/4) when dry; moderate, fine and very fine, subangular blocky structure; slightly hard, friable, sticky and plastic; few fine roots; many fine and medium pores; nearly continuous, thin coatings on peds; common, hard, sand-size aggregates that are resistant to crushing; about 5 percent cobblestones and stones; few, fine, black concretions; strong effervescence with hydrogen peroxide; neutral; clear, wavy boundary. 7 to 10 inches thick.

IIC—18 inches, fragmental Aa lava that contains a little soil material in the voids.

The depth of the soil over fragmental Aa lava ranges from 12 to 30 inches. Stones cover 3 to 15 percent of the surface. The A horizon ranges from 5YR to 7.5YR in hue, from 3 to 4 in value when moist, and from 2 to 3 in chroma when moist and 3 to 4 when dry. The B horizon ranges from 3 to 4 in value when dry and from 3 to 4 in chroma when moist. The texture is silty clay loam or silty clay. In a few places the lower part of the B horizon and the IIC horizon effervesce with hydrochloric acid.

This soil is used for pasture and wildlife habitat. (Capability classification VIs, nonirrigated; pasture group 1)

Kekaha Series

This series consists of well-drained soils on alluvial fans and flood plains on the island of Kauai. These soils developed in alluvium washed from upland soils. They are nearly level to steep. Elevations range from nearly sea level to 150 feet. The annual rainfall amounts to 20 to 25 inches. The mean annual soil temperature is 74° F. Kekaha soils are geographically associated with Lualualei and Nohili soils.

These soils are used for irrigated sugarcane, pasture, and wildlife habitat. The natural vegetation consists of koa haole, kiawe, klu, and fingergrass.

Kekaha silty clay, 0 to 2 percent slopes (KoA).—This soil is on flood plains and alluvial fans. Included in mapping were small areas of stony soils.

In a representative profile the surface layer is dark reddish-brown silty clay about 21 inches thick. The subsoil is dark reddish-brown silty clay and clay more than 49 inches thick. The substratum is clayey alluvium. The soil is mildly alkaline to neutral throughout the profile.

Permeability is moderate. Runoff is slow, and there is no erosion hazard. The available moisture capacity is about 1.8 inches per foot of soil. In places roots penetrate to a depth of 5 feet or more.

Representative profile: Island of Kauai, lat. 21°59′0″ N. and long. 159°43′19″ W.

Ap1—0 to 7 inches, dark reddish-brown (5YR 3/2) silty clay, dark reddish brown (5YR 3/3) when dry; moderate, fine and very fine, granular structure; very hard, friable, sticky and plastic; plentiful roots; strong effervescence with hydrogen peroxide; mildly alkaline; clear, smooth boundary. 6 to 8 inches thick.

Ap2—7 to 14 inches, dark reddish-brown (5YR 3/3), moist and dry, silty clay; weak and moderate, fine and very fine, subangular blocky structure; very hard, friable, sticky and plastic; plentiful roots; moderate effervescence with hydrogen peroxide; mildly alkaline; clear, smooth boundary. 6 to 8 inches thick.

A1b—14 to 21 inches, dark reddish-brown (5YR 3/3) silty clay; bands of dark reddish brown (5YR 2/2), reddish brown (5YR 4/4) when dry; weak, fine, subangular blocky structure; hard, friable, sticky and plastic; plentiful roots; many fine and medium pores; thin, patchy clay coatings in pores and on peds; moderate effervescence with hydrogen peroxide; mildly alkaline; abrupt, smooth boundary. 6 to 9 inches thick.

B21—21 to 28 inches, dark reddish-brown (5YR 3/3) silty clay, dark reddish brown (5YR 3/4) when dry; massive; medium, subangular blocky structure in places; very hard, firm, sticky and plastic; few roots; many fine and medium pores; moderate effervescence with hydrogen peroxide; mildly alkaline; gradual, wavy boundary. 5 to 9 inches thick.

B22—28 to 44 inches, dark reddish-brown (2.5YR 3/4) clay, reddish brown (2.5YR 4/3) when dry; weak, medium and coarse, prismatic structure; very hard, firm, sticky and plastic; few roots; many fine and medium pores; moderate effervescence with hydrogen peroxide; mildly alkaline; gradual, wavy boundary. 12 to 20 inches thick.

B23—44 to 70 inches, dark reddish-brown (2.5YR 3/4) clay, weak red (2.5YR 4/2) when dry; weak, medium, subangular blocky structure; hard, firm, sticky and plastic; few roots; many fine pores; common patchy pressure cutans; vertical channels that exhibit coatings that look like clay films; moderate effervescence with hydrogen peroxide; neutral.

In places the A horizon is extremely stony or is clay. The B horizon ranges from 2.5YR to 5YR in hue.

This soil is used for irrigated sugarcane and pasture. (Capability classification I if irrigated, IVc if nonirrigated; sugarcane group 1; pasture group 2; woodland group 4)

Kekaha silty clay, 2 to 6 percent slopes (KoB).—On this soil, runoff is medium and the erosion hazard is slight to moderate. Included in mapping were a few small areas of stony soils and small areas where the slope is more than 6 percent.

This soil is used for irrigated sugarcane and pasture. (Capability classification IIe if irrigated, IVc if nonirrigated; sugarcane group 1; pasture group 2; woodland group 4)

Kekaha clay, 0 to 2 percent slopes (KobA).—This soil is underlain by marine clay and has mottles in the subsoil. Workability is difficult. Runoff is slow, and there is no erosion hazard.

This soil is used for irrigated sugarcane and pasture. (Capability classification I if irrigated, IVc if nonirrigated; sugarcane group 1; pasture group 2; woodland group 4)

Kekaha extremely stony silty clay loam, 0 to 35 percent slopes (KOYE).—On this soil, runoff is slow to medium and the erosion hazard is no more than moderate.

This soil is used for pasture and wildlife habitat. (Capability classification VIs, nonirrigated; pasture group 2; woodland group 4)

Kemoo Series

This series consists of well-drained soils on uplands on the island of Oahu. These soils developed in material weathered from basic igneous rock. They are gently sloping to very steep. Elevations range from 300 to 1,200 feet. The annual rainfall amounts to 35 to 60 inches, most of which occurs between November and April. The mean annual soil temperature is 71° F. Kemoo soils occur mainly on the windward slopes of the Waianae Range and from Waimea Bay to Kahuku on the Koolau Range. They are geographically associated with Halawa, Mahana, and Paumalu soils.

These soils are used mainly for pasture. Small areas are used for sugarcane. The natural vegetation consists of guava, koa haole, Christmas berry, lantana, and bermudagrass.

Kemoo silty clay, 12 to 20 percent slopes (KpD).—This soil occurs on uplands. Included in mapping were small areas of silty clay loam or silt loam. These areas are at the higher elevations. The soils in these included areas have a concentration of heavy minerals in the surface layer. Also included were small, eroded spots and stony areas.

In a representative profile the surface layer is very dusky red to dark reddish-brown, subangular blocky silty clay about 12 inches thick. The subsoil, about 55 inches thick, is dark reddish-brown to dusky-red silty clay that has subangular blocky structure. The substratum is soft, weathered rock. The soil is slightly acid in the surface layer and slightly acid to neutral in the subsoil.

Permeability is moderate to moderately rapid. Runoff is medium, and the erosion hazard is moderate. The available water capacity is 1.4 inches per foot of soil. Workability is slightly difficult because of the slope. In places roots penetrate to a depth of 5 feet or more.

Representative profile: Island of Oahu, lat. 21°33′00″ N. and long. 158°07′23″ W.

Ap1—0 to 4 inches, very dusky red (2.5YR 2/2) silty clay, dusky red (2.5YR 3/2) when dry; moderate, very fine, granular and subangular blocky structure; very hard, firm, sticky and plastic; abundant fine, medium, and coarse roots; common, very fine and fine, interstitial and tubular pores; strong effervescence with hydrogen peroxide; slightly acid; clear, smooth boundary. 3 to 5 inches thick.

Ap2—4 to 12 inches, dark reddish-brown (2.5YR 3/4), moist and dry, silty clay; strong, very fine and fine, subangular blocky structure; hard, firm, sticky and plastic; abundant fine, medium, and coarse roots; many, very fine, tubular pores; strong effervescence with hydrogen peroxide; slightly acid; gradual, smooth boundary. 6 to 9 inches thick.

B1—12 to 20 inches, dark reddish-brown (2.5YR 3/4) silty clay, dark red (2.5YR 3/6) when dry; moderate, medium, subangular blocky structure breaking to strong, fine and very fine, subangular blocky; hard, firm, sticky and plastic; abundant fine, medium, and coarse roots; many, very fine, tubular pores; thin, patchy clay films on ped faces; slight effervescence with hydrogen peroxide; slightly acid; abrupt, smooth boundary. 6 to 8 inches thick.

B21t—20 to 34 inches, dark reddish-brown (2.5YR 3/4) silty clay, dark red (2.5YR 3/6) when dry; moderate, medium, subangular blocky structure breaking to strong, very fine, subangular and angular blocky; slightly hard, friable, sticky and very plastic; common medium and fine roots; many, very fine and fine, tubular pores; thin, continuous clay films on ped faces and a few lined pores; slight effervescence with hydrogen peroxide; neutral; clear, wavy boundary. 12 to 14 inches thick.

B22t—34 to 58 inches, dusky-red (10YR 3/4) silty clay, dark red (10R 3/4) when dry; moderate, medium and coarse, subangular blocky structure breaking to strong, fine and very fine, angular and subangular blocky; hard but brittle, friable, sticky and very plastic; many medium, few fine and coarse roots; common, very fine and fine, tubular pores; moderately thick, continuous clay films on ped faces and in pores; few slickensides; slight effervescence with hydrogen peroxide; neutral; gradual, smooth boundary. 20 to 26 inches thick.

B23t—58 to 66 inches, dusky-red (10R 3/4) silty clay, dark red (10R 3/4) when dry; moderate, medium and coarse, subangular blocky structure breaking to strong, fine and very fine, angular and subangular blocky; hard but brittle, friable, sticky and very plastic; few coarse roots; many, very fine, tubular pores; moderately thick, continuous clay films on ped faces and in pores; common slickensides; slight effervescence with hydrogen peroxide; neutral.

In most places there are no manganese concretions within the solum. In places there are a few stones or boulder cores. The A horizon ranges from 5YR to 2.5YR in hue, from 2 to 3 in value when moist or dry, and from 2 to 4 in chroma when moist or dry. The B horizon ranges from 2.5YR to 10R in hue and from 4 to 6 in chroma when dry.

This soil is used mainly for pasture. Small areas at lower elevations are used for sugarcane. (Capability classification IVe, nonirrigated; sugarcane group 1; pineapple group 6; pasture group 5; woodland group 5)

Kemoo silty clay, 2 to 6 percent slopes (KpB).—On this soil, runoff is slow to medium and the erosion hazard is slight. Workability is easy.

This soil is used for sugarcane and pasture. (Capability classification IIe, nonirrigated; sugarcane group 1; pineapple group 5; pasture group 5; woodland group 5)

Kemoo silty clay, 6 to 12 percent slopes (KpC).—On this soil, runoff is medium and the erosion hazard is slight to moderate. Workability is slightly difficult because of the slope. Included in mapping were small, eroded areas.

This soil is used for sugarcane and pasture. (Capability classification IIIe, nonirrigated; sugarcane group 1; pineapple group 6; pasture group 5; woodland group 5)

Kemoo silty clay, 20 to 35 percent slopes (KpE).—On this soil, runoff is medium to rapid and the erosion hazard is moderate to severe. Workability is difficult because of the slope. Included in mapping were small, eroded spots and areas of Stony land and of Rock outcrop.

This soil is used for pasture. (Capability classification VIe, nonirrigated; pasture group 5; woodland group 5)

Kemoo silty clay, 35 to 70 percent slopes (KpF).—This soil occurs on side slopes along drainageways. Runoff is rapid, and the erosion hazard is severe. Included in mapping were small, eroded spots, stony areas, and outcrops.

This soil is used for pasture. (Capability classification VIIe, nonirrigated; pasture group 5; woodland group 15)

Kemoo-Badland complex (KPZ).—Kemoo silty clay makes up 40 to 80 percent of this complex. The slope ranges from 10 to 70 percent. Runoff is medium to rapid, and the erosion hazard is moderate to severe. Badland consists of nearly barren areas that have remained after removal of the Kemoo soil by erosion. On this soil, runoff is rapid and the erosion hazard is very severe. About 80 percent of Badland is oriented in the direction of the trade winds.

Included in mapping were small areas of Rock outcrop, Stony land, Stony steep land, and Rock land.

This complex is used for pasture. (Kemoo part is in capability classification VIIe, nonirrigated; pasture group 5; woodland group 5. Badland part is in capability classification VIIIe)

Koele Series

This series consists of well-drained soils on fans and in drainageways on the islands of Lanai, Maui, and Molokai. These soils formed in alluvium derived from basic igneous material. They are gently sloping to steep. Elevations are mainly between 1,000 and 2,000 feet, but some areas are near sea level. The annual rainfall amounts to 15 to 35 inches, except that on Maui it amounts to 35 to 50 inches. Most of the rainfall occurs from November to April. The mean annual soil temperature is about 68° F. Koele soils are geographically associated with Alaeloa, Kanepuu, and Lahaina soils.

These soils are used for pineapple, pasture, and wildlife habitat. The natural vegetation consists of lantana, Natal redtop, dallisgrass, molassesgrass, and pilipiliula.

Koele silty clay loam, 3 to 7 percent slopes (KrB).—This soil occurs on fans and in drainageways.

In a representative profile the surface layer is dark-brown silty clay loam about 18 inches thick. The next layer, 30 to more than 40 inches thick, consists of stratified, dark-brown alluvium that ranges from silty clay loam to coarse sandy loam in texture. The soil is slightly acid to medium acid, except that the surface layer is generally very strongly acid in areas used for pineapple.

Permeability is moderately rapid. Runoff is slow to medium, and the erosion hazard is slight to moderate. The available water capacity is about 1.6 inches per foot of soil. In places roots penetrate to a depth of 5 feet or more.

Representative profile: Island of Lanai, lat. 20°51′54″ N. and long. 156°57′07″ W.

Ap—0 to 18 inches, dark-brown (7.5YR 3/2) silty clay loam, brown (7.5YR 4/2) when dry; strong, fine, subangular blocky structure breaking to strong, fine, granular; hard, friable, slightly sticky and slightly plastic; many fine and medium roots; many, fine and medium, interstitial pores; 15 percent pebble-size rock fragments; moderate effervescence with hydrogen peroxide; very strongly acid; abrupt, smooth boundary. 17 to 19 inches thick.

AC—18 to 33 inches, dark-brown (7.5YR 3/2) silty clay loam, brown (7.5YR 4/2) when dry; weak, fine, subangular blocky structure; hard, friable, slightly sticky and slightly plastic; very few roots in upper part; com-

mon interstitial pores; 20 percent pebble-size rock fragments; moderate effervescence with hydrogen peroxide; medium acid; abrupt, wavy boundary. 13 to 17 inches thick.

C1—33 to 36 inches, dark-brown (7.5YR 3/2) sandy clay loam, dark reddish gray (5YR 4/2) when dry; massive; hard, friable, slightly sticky and slightly plastic; 80 percent coarse sand and fine gravel; no effervescence with hydrogen peroxide; medium acid; abrupt, wavy boundary. 2 to 5 inches thick.

IIC2—36 to 43 inches, dark-brown (7.5YR 3/2) silt loam, brown (7.5YR 4/2) when dry; weak, very fine, subangular blocky structure; hard, friable, slightly sticky and slightly plastic; common, fine, interstitial pores; 20 percent fine sand and fine gravel in pockets; slightly acid; clear, wavy boundary. 5 to 9 inches thick.

IIIC3—43 to 55 inches, dark-brown (7.5YR 3/2), stratified fine sand and coarse sandy loam, brown (7.5YR 4/2) when dry; single grain, but some parts are massive; soft, friable, slightly sticky and slightly plastic; common, fine, weathered rock particles that break down to clay loam after prolonged rubbing; slightly acid.

The depth to bedrock is more than 5 feet. In some places a few stones and coarse gravel occur on the surface and throughout the profile. The thickness, texture, and consistence of the layers in the C horizon vary considerably within a short distance. The texture of the layers is fine sand, coarse sandy loam, coarse sandy clay loam, silt loam, or silty clay loam. The thickness of the contrasting textural layers ranges from ½ inch to more than 12 inches.

Nearly all of this soil is used for pineapple. (Capability classification IIe if irrigated, IIIc if nonirrigated; pineapple group 2; pasture group 3)

Koele silty clay loam, 7 to 15 percent slopes (KrC).—On this soil, runoff is medium and the erosion hazard is moderate. Workability is slightly difficult because of the slope.

This soil is used for pineapple and wildlife habitat. (Capability classification IIIe, irrigated or nonirrigated; pineapple group 3; pasture group 3)

Koele silty clay loam, 15 to 25 percent slopes (KrD).—This soil occurs on foot slopes adjacent to very steep mountainsides. Runoff is medium, and the erosion hazard is moderate to severe. Workability is difficult because of the slope. There are a few gullies.

This soil is used for pasture and wildlife habitat. (Capability classification IVe, irrigated or nonirrigated; pineapple group 3; pasture group 3)

Koele-Badland complex (KRL).—This complex occurs mainly in large gulches. It consists of Koele soils at the bottoms of gulches and Badland on the sides of gulches. The Koele soils are similar to Koele silty clay loam, 3 to 7 percent slopes, except that the slope is mainly 7 to 20 percent. These soils make up 60 to 80 percent of the acreage. Badland consists of highly weathered rock, mainly along the sides of gulches. It makes up 20 to 40 percent of the acreage. The slope is 40 to 70 percent. There are a few rock outcrops and scattered stones and boulders. In most places there are many deep, vertical gullies on the Koele soils where the slope is more than 10 percent. The Koele soils are easily eroded if they are bare of vegetation. Vegetation on these soils consists of molassesgrass, dallisgrass, pilipiliula, lantana, and Natal redtop. The Badland part of this complex has little vegetation, and many of the areas are bare.

A small area of this complex occurs near Cape Halawa, Molokai. It is at elevations ranging from nearly sea level to 500 feet. Another area occurs in Lanai at elevations of more than 1,000 feet.

This complex is used for pasture and wildlife habitat. (Koele part is in capability classification VIe, nonirrigated; pasture group 3. Badland part is in capability classification VIIIe)

Koele rocky complex (KRX).—This complex occurs near Nakalele Point on West Maui. The topography is hilly. The slope is mainly 20 to 35 percent but ranges from 15 to 60 percent. The Koele soils have a profile like that of Koele silty clay loam, 3 to 7 percent slopes, except that the texture throughout the profile is mainly clay loam. These soils make up 30 to 50 percent of the complex. The remaining area consists of rocky gulches and knolls. Stony areas are common, especially on knolls. Most areas are covered with brushy vegetation, such as lantana, guava, and Christmas berry. Grasses are common among the brush. A few areas are bare, and wind and water erosion are active.

This complex is used for pasture. (Capability classification VIs, nonirrigated; pasture group 3)

Kokee Series

This series consists of well-drained soils on uplands on the island of Kauai. These soils developed in material weathered from basic igneous rock, probably mixed with volcanic ash. They are gently sloping to very steep. Elevations range from 3,400 to 4,200 feet. The annual rainfall amounts to 60 to 70 inches. The mean annual soil temperature is 59° F. Kokee soils are geographically associated with Paaiki and Kunuweia soils.

These soils are used for water supply, wildlife habitat, and woodland. The natural vegetation consists of ohialehua, puakeawe, blackberry, yellow foxtail, koa, plantain, uki uki, redwood, and associated plants.

Kokee silty clay loam, 0 to 35 percent slopes (KSKE).—This soil is undulating to steep and occurs on uplands. Included in mapping were some small, narrow areas of alluvial soils.

In a representative profile the surface layer, about 8 inches thick, is dark-brown silty clay loam and silt loam that has subangular blocky structure. The subsoil, about 34 inches thick, is strong-brown and dark-brown silty clay loam and silty clay that has subangular blocky structure. The substratum is soft, weathered rock. The soil is very strongly acid throughout the profile.

Permeability is moderately rapid. Runoff is medium, and the erosion hazard is slight to moderate. Roots penetrate to a depth of 20 inches or more, depending on the depth to weathered rock.

Representative profile: Island of Kauai, lat. 22°07′59.6″ N. and long. 159°39′22.8″ W.

A11—0 to 4 inches, dark-brown (7.5YR 3/2) silty clay loam, brown (7.5YR 4/2) when dry; moderate, fine and very fine, subangular blocky structure; hard, friable, sticky and plastic; abundant roots; moderate, delayed effervescence with hydrogen peroxide; very strongly acid; clear, smooth boundary. 4 to 8 inches thick.

A12—4 to 8 inches, dark-brown (7.5YR 3/3) silt loam, brown (7.5YR 4/3) when dry; weak, fine, subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; abundant roots; many fine pores; slight, delayed effervescence with hydrogen

peroxide; very strongly acid; clear, smooth boundary. 0 to 5 inches thick.

B1—8 to 14 inches, dark-brown (7.5YR 4/4) silty clay loam, strong brown (7.5YR 5/6) when dry; weak, fine, subangular blocky structure; slightly hard, friable, sticky and plastic, and weakly smeary; abundant roots; many fine and very fine pores; slight, delayed effervescence with hydrogen peroxide; very strongly acid; clear, smooth boundary. 0 to 6 inches thick.

B21t—14 to 23 inches, strong-brown (7.5YR 5/6) heavy silty clay loam, dark brown (7.5YR 4/4) when dry; moderate, fine and very fine, subangular blocky structure; slightly hard, friable, sticky and plastic, and weakly smeary; plentiful roots; many fine pores; thin, nearly continuous clay films on peds and in pores; conspicuous, yellowish, "sugary" coatings; weak pressure cutans; very strongly acid; gradual, smooth boundary. 8 to 12 inches thick.

B22t—23 to 32 inches, dark-brown (7.5YR 5/4) heavy silty clay loam, strong brown (7.5YR 4/6) when dry; strong, very fine, subangular and angular blocky structure; slightly hard, friable, sticky and plastic; plentiful roots; many fine pores; thin, patchy clay films; conspicuous, yellow, "sugary" coatings; weak pressure cutans; very strongly acid; clear, wavy boundary. 8 to 13 inches thick.

B23t—32 to 42 inches, dark-brown (10YR 4/3) silty clay, brown (7.5YR 4/4) when dry; strong, fine and very fine, angular and subangular blocky structure; hard, firm, very sticky and very plastic; few roots; many fine pores; thin, patchy clay films; conspicuous, yellow, "sugary" coatings; very strongly acid; clear, wavy boundary. 8 to 12 inches thick.

C—42 inches, hard and soft, weathered rock. The hard material is gray (5YR 5/1), light gray (N 7/0) when dry. It has many black coatings in pores, as well as some red, orange, and light-yellow coatings. The soft material is dark-brown (7.5YR 4/2) silty clay; firm, sticky and plastic; few roots; many fine pores; very strongly acid.

The A horizon ranges from 7.5YR to 10YR in hue, from 2 to 3 in chroma, and from 2 to 3 in value. The A12 and B1 horizons are lacking in some profiles. The B2 horizon ranges from 7.5YR to 10YR in hue, from 3 to 6 in chroma, and from 3 to 4 in value. The depth to weathered rock ranges from 28 to more than 56 inches.

This soil is used for water supply, wildlife habitat, and woodland. (Capability classification VIe, nonirrigated; pasture group 12; woodland group 10)

Kokee silty clay loam, 35 to 70 percent slopes (KSKF).—On this soil, runoff is rapid and the erosion hazard is severe.

This soil is used for water supply, wildlife habitat, and woodland. (Capability classification VIIe, nonirrigated; pasture group 12; woodland group 10)

Koko Series

This series consists of well-drained soils on fans and volcanic spurs on the island of Oahu. These soils developed in alluvium washed from deposits of volcanic ash, cinders, and tuff. They are gently sloping to moderately steep. Elevations range from nearly sea level to 200 feet. The annual rainfall amounts to 15 to 25 inches, most of which occurs between November and April. The mean annual soil temperature is 74° F. Koko soils occur near Koko Head, Koko Crater, and Diamond Head. They are geographically associated with Lualualei soils.

These soils are used for homesites, pasture, and truck crops. The natural vegetation consists of kiawe, klu, koa haole, fingergrass, and bristly foxtail.

Koko silt loam, 2 to 6 percent slopes (KsB).—This soil occupies smooth slopes. Included in mapping were small eroded spots, small nearly level areas, and small areas that have a buried profile. Gravelly soils are on foot slopes and along drainageways.

In a representative profile the surface layer is dark reddish-brown silt loam about 16 inches thick. The subsoil, about 32 inches thick, is dark reddish-brown or dark-brown silt loam, loam, or clay loam that has subangular blocky structure. The substratum consists of cinders and tuff. The soil is neutral in reaction throughout the profile.

Permeability is moderate. Runoff is slow, and the erosion hazard is slight. The available water capacity is 2.1 inches per foot of soil. In places roots penetrate to a depth of 5 feet or more.

Representative profile: Island of Oahu, lat. 21°16′48″ N. and long. 157°42′12″ W.

Ap—0 to 8 inches, dark reddish-brown (5YR 3/3) silt loam, reddish brown (5YR 4/4) when dry; weak, very fine and fine, granular structure; slightly hard, very friable, nonsticky and slightly plastic; plentiful very fine, and few medium roots; common, very fine, interstitial pores; neutral; gradual, smooth boundary. 5 to 9 inches thick.

A1—8 to 16 inches, dark reddish-brown (5YR 3/3) silt loam, reddish brown (5YR 4/4) when dry; weak, fine and medium, subangular blocky structure breaking to weak, fine, granular; slightly hard, very friable, slightly sticky and slightly plastic; plentiful very fine and medium roots; common, very fine and medium, tubular pores; neutral; clear, smooth boundary. 8 to 10 inches thick.

B21—16 to 25 inches, dark reddish-brown (5YR 3/4) silt loam, reddish brown (5YR 4/4) when dry; weak, fine and medium, subangular blocky structure; slightly hard, very friable, sticky and plastic; plentiful very fine and medium roots; common, very fine and medium, tubular pores; neutral; gradual, smooth boundary. 8 to 11 inches thick.

B22—25 to 33 inches, dark reddish-brown (5YR 3/4) clay loam, reddish brown (5YR 4/4) when dry; moderate, fine to coarse, subangular blocky structure; slightly hard, friable, sticky and plastic; plentiful fine, and few medium and coarse roots; common, fine, tubular pores and few, medium and coarse, tubular pores; neutral; gradual, smooth boundary. 6 to 10 inches thick.

B23—33 to 41 inches, dark reddish-brown (5YR 3/4) clay loam, yellowish red (5YR 4/6) when dry; moderate, fine and medium, subangular blocky structure; hard, firm, sticky and plastic; plentiful very fine and fine, common fine, and few coarse roots; common, fine and medium, tubular pores and few, coarse, tubular pores; neutral; clear, wavy boundary. 6 to 8 inches thick.

B3—41 to 48 inches, dark-brown (7.5YR 4/4) loam, strong brown (7.5YR 5/6) when dry; weak, fine and medium, subangular blocky structure; slightly hard, friable, sticky and plastic; few fine roots; few, fine and medium, tubular pores; common fine cinder fragments; neutral. 4 to 8 inches thick.

IIC—48 inches, cinders and tuff.

The depth to tuff and cinders ranges from 37 to 56 inches. Fragments of tuff are common in the profile on the windward side of craters. The texture of the solum is silt loam, loam, clay loam, or silty clay loam. The B horizon ranges from 5YR to 7.5YR in hue, from 3 to 4 in value when moist and from 4 to 5 when dry. It ranges from 4 to 5 in chroma when moist and from 4 to 8 when dry.

This soil is used for homesites, truck crops, and pasture. (Capability classification IIe if irrigated, VIe if nonirrigated; pasture group 2)

Koko silt loam, 6 to 12 percent slopes (KsC).—On this soil, runoff is medium and the erosion hazard is moderate. Workability is slightly difficult because of the slope.

This soil is used for homesites and pasture. (Capability classification IIIe if irrigated, VIe if nonirrigated; pasture group 2)

Koko silt loam, 12 to 25 percent slopes (KsD).—This soil is similar to Koko silt loam, 2 to 6 percent slopes, except that it is on fans on foot slopes of volcanic craters. Runoff is medium to rapid, and the erosion hazard is moderate to severe. Workability is difficult because of the slope.

This soil is used for homesites and pasture. (Capability classification IVe if irrigated, VIe if nonirrigated; pasture group 2)

Kokokahi Series

This series consists of moderately well drained soils on talus slopes and alluvial fans on the island of Oahu. These soils developed in colluvium and alluvium derived from basic igneous rock. They are moderately sloping to steep. Elevations range from nearly sea level to 125 feet. The annual rainfall amounts to 20 to 35 inches. The mean annual soil temperature is 74° F. Kokokahi soils occur in the vicinity of Kaneohe and Pearl Harbor and are geographically associated with Alaeloa and Jaucas soils.

These soils are used for pasture and homesites. The natural vegetation consists of kiawe, koa haole, klu, bristly foxtail, piligrass, and bermudagrass.

Kokokahi clay, 6 to 12 percent slopes (KtC).—This soil is on talus slopes and alluvial fans. Included in mapping were small areas where the slope is 2 to 6 percent and small areas along drainageways where the slope is 20 to 35 percent. Also included were wet soils within drainageways.

In a representative profile the surface layer is very dark gray and dark gray clay about 14 inches thick. The next layer, about 12 inches thick, is dark grayish-brown clay that has subangular blocky structure. The substratum is grayish-brown and light brownish-gray clay 14 to more than 20 inches thick. These soils are very sticky and very plastic, and they crack widely upon drying. They are slightly acid to neutral in the surface layer and slightly acid to mildly alkaline below.

Permeability is slow to moderately slow. Runoff is medium, and the erosion hazard is slight to moderate. The available water capacity is about 1.6 inches per foot of soil. In places roots penetrate to a depth of 5 feet or more. Workability is difficult because of the sticky, plastic nature of the clay and the narrow range of moisture content within which the soil can be cultivated. The shrink-swell potential is high.

Representative profile: Island of Oahu, lat. 21°25′48″ N. and long. 157°45′52″ W.

A11—0 to 2 inches, very dark gray (10YR 3/1), moist and dry, clay; strong, fine, granular structure; extremely hard, very firm, very sticky and very plastic; abundant fine and very fine roots; common, very fine, tubular and interstitial pores; common, fine, black concretions; few, fine, angular fragments of basalt; moderate effervescence with hydrogen peroxide; slightly acid; clear, smooth boundary. 1 to 3 inches thick.

A12—2 to 14 inches, dark-gray (10YR 4/1), moist and dry, clay; strong, fine, subangular blocky structure; very hard, very firm, very sticky and very plastic; plentiful very fine roots and few medium roots; common, very fine and fine, tubular pores; few, fine, black concretions; few, fine, angular fragments of basalt; moderate effervescence with hydrogen peroxide; neutral; gradual, smooth boundary. 8 to 12 inches thick.

AC—14 to 26 inches, dark grayish-brown (2.5Y 4/2), moist and dry, clay; irregularly shaped large blocks that break to moderate, fine, subangular blocky structure; extremely hard, very firm, very sticky and very plastic; common very fine roots and few medium roots; many, very fine, tubular pores; many distinct slickensides; common black stains; slight effervescence with hydrogen peroxide; few pebble-size fragments of basalt; mildly alkaline; gradual, smooth boundary. 10 to 14 inches thick.

C1—26 to 38 inches, grayish-brown (2.5Y 5/2), moist and dry, clay; large irregularly shaped blocks that break to moderate, fine and medium, subangular blocky structure; extremely hard, very firm, very sticky and very plastic; few very fine roots; few, very fine, tubular pores; common deeply grooved slickensides; common black stains; few pebble-size fragments of basalt; common fine gypsum crystals; slight effervescence with hydrogen peroxide; neutral; abrupt, smooth boundary. 8 to 14 inches thick.

C2—38 to 44 inches, light brownish-gray (2.5YR 6/2) clay, olive brown (2.5YR 4/3) when dry; weak, medium, subangular blocky structure; hard, friable, slightly sticky and slightly plastic; few very fine roots; common, very fine and fine, tubular pores; slightly acid.

A few stones occur throughout the profile. The AC horizon ranges from 2.5Y to 5Y in hue, from 3 to 5 in value when moist, and from 2 to 4 in chroma. Wide, deep cracks (2 inches or more wide and 20 to 30 inches deep) are common when the soil is dry.

This soil is used for pasture and homesites. (Capability classification VIe, nonirrigated; pasture group 3)

Kokokahi very stony clay, 0 to 35 percent slopes (KTKE).—This soil is similar to Kokokahi clay, 6 to 12 percent slopes, except that there are many stones and boulders on the surface and throughout the profile. In most places the slope ranges from 10 to 25 percent. Runoff is medium to rapid, and the erosion hazard is moderate to severe.

This soil is used for pasture. It is generally too stony for cultivated crops. (Capability classification VIs, nonirrigated; pasture group 3)

Kolekole Series

This series consists of well-drained soils on uplands on the island of Oahu. These soils developed in old gravelly alluvium mixed with volcanic ash. They are gently sloping to moderately steep. Elevations range from 500 to 1,200 feet. The annual rainfall amounts to 35 to 50 inches, most of which occurs between November and April. The mean annual soil temperature is 71° F. Kolekole soils occur on the windward slopes of the Waianae Range. They are geographically associated with Kunia, Mahana, and Wahiawa soils.

These soils are used for sugarcane, pineapple, and pasture. The natural vegetation consists of guava, lantana, bermudagrass, and Natal redtop.

Kolekole silty clay loam, 1 to 6 percent slopes (KuB).—This soil occurs on smooth slopes. Included in mapping

were small areas of Kunia and Mahana soils, small eroded spots, and steep side slopes along drainageways.

In a representative profile the surface layer is dark reddish-brown silty clay loam about 12 inches thick. The subsoil, about 48 inches thick, is dark reddish-brown silty clay loam and silty clay that has subangular and angular blocky structure. The substratum is old gravelly alluvium. A compact, panlike layer typically occurs at a depth of 24 to 40 inches. The soil is extremely acid to strongly acid in the surface layer and medium acid to very strongly acid in the subsoil.

Permeability is moderately rapid to the panlike layer and moderate in the compact subsoil. Runoff is slow, and the erosion hazard is slight. The available water capacity is about 1.3 inches per foot of soil. Roots are restricted by the compact layer.

Representative profile: Island of Oahu, lat. 21°26′48″ N. and long. 158°03′47″ W.

Ap1—0 to 4 inches, dark reddish-brown (5YR 3/3) silty clay loam, reddish brown (5YR 4/4) when dry; weak, fine and very fine, granular structure; slightly hard, very friable, slightly sticky and slightly plastic; abundant fine roots; many, very fine, interstitial pores; common, very fine, shiny specks; common, very fine, earthy lumps that are difficult to rub down; very slight effervescence with hydrogen peroxide; extremely acid; clear, smooth boundary. 3 to 9 inches thick.

Ap2—4 to 12 inches, dark reddish-brown (5YR 3/3) silty clay loam, reddish brown (5YR 4/4) when dry; weak, fine and medium, subangular blocky structure and weak, very fine, granular; slightly hard, very friable, slightly sticky and slightly plastic; abundant fine roots; common, very fine, tubular and interstitial pores; many, very fine, earthy lumps that are difficult to break down; dark reddish-brown (2.5YR 3/4) material from horizon below (10 percent); common, very fine, shiny specks; extremely acid; clear, wavy boundary. 7 to 10 inches thick.

B21—12 to 20 inches, dark reddish-brown (2.5YR 3/4) silty clay loam, dark red (2.5YR 3/6) when dry; moderate, very fine and fine, subangular and angular blocky structure; very hard, friable, sticky and plastic; plentiful fine roots; common, fine and very fine, tubular pores; few, fine, earthy lumps; few shiny specks; medium acid; gradual, smooth boundary. 6 to 8 inches thick.

B22—20 to 25 inches, dark reddish-brown (2.5YR 3/4) silty clay loam, dark red (2.5YR 3/6) when dry; moderate, very fine and fine, subangular and angular blocky structure; hard, firm, sticky and plastic; few fine roots; common, very fine and fine, tubular pores; few, very fine, earthy lumps; patchy pressure cutans on ped surfaces; few, very fine, shiny specks; strongly acid; gradual, smooth boundary. 2 to 7 inches thick.

B23—25 to 32 inches, dark reddish-brown (2.5YR 3/4) silty clay loam, dark red (2.5YR 3/6) when dry; moderate, very fine and fine, subangular blocky structure; hard, firm, sticky and plastic; few fine roots; common, fine, tubular pores; weak, continuous pressure cutans on ped surfaces; few earthy lumps; few shiny specks; very strongly acid; clear, smooth boundary. 6 to 8 inches thick.

B24—32 to 38 inches, dark reddish-brown (2.5YR 3/4) silty clay, red (2.5YR 5/8) when dry; weak, fine and very fine, subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; few fine roots; common very fine, fine, and medium pores; few, thin, patchy clay films; few, very fine, earthy lumps; few shiny specks; very strongly acid; abrupt, wavy boundary. 2 to 6 inches thick.

B25tb—38 to 60 inches, dark reddish-brown (5YR 3/3) silty clay loam, dark reddish brown (5YR 3/4) when moist; strong, very fine and fine, subangular and angular blocky structure; very hard, friable, sticky and plastic; compact in place; horizon is capped by a massive, banded, brittle pan (1/16 inch to 3/8 inch thick) that has a troweled surface; no roots; very few, very fine, tubular pores; continuous, strong pressure cutans on all ped surfaces that increase with depth; many rock cores that retain original form; common light-colored sand grains; continuous dark-red and red clay films on about 50 percent of ped faces; very strongly acid.

The greatest variation in the series is in the depth to the panlike layer. The depth to this layer is typically 24 to 40 inches, but it ranges from 15 to 50 inches. The A horizon ranges from 2 to 3 in value and chroma when moist and from 3 to 4 when dry. The B horizon, above the B25tb, ranges from 2 to 3 in value when moist and from 3 to 5 when dry. It ranges from 4 to 6 in chroma when moist and from 4 to 8 when dry. The B25tb horizon ranges from silty clay loam to silty clay in texture. It is capped by a brittle, banded, panlike layer that forms an abrupt boundary with the upper part of the B horizon. A black, thick layer of decomposed roots, 1/4 to 1/2 inch thick, commonly rests on the pan. The amount of highly weathered rock fragments varies considerably within short distances but normally makes up between 30 and 40 percent of the volume.

This soil is used for sugarcane, pineapple, and pasture. (Capability classification IIe if irrigated, IIIe if nonirrigated; sugarcane group 1; pineapple group 5; pasture group 6; woodland group 6)

Kolekole silty clay loam, 6 to 12 percent slopes (KuC).—On this soil, runoff is medium and the erosion hazard is moderate. Workability is slightly difficult because of the slope.

This soil is used for sugarcane, pineapple, and pasture. (Capability classification IIIe, irrigated or nonirrigated; sugarcane group 1; pineapple group 6; pasture group 6; woodland group 6)

Kolekole silty clay loam, 12 to 25 percent slopes (KuD).—This soil occurs on narrow side slopes, mainly along drainageways. Runoff is medium to rapid, and the erosion hazard is moderate to severe. Workability is difficult because of the slope. Included in mapping were small, eroded spots.

This soil is used for pasture and pineapple. (Capability classification IVe, irrigated or nonirrigated; sugarcane group 1; pineapple group 6; pasture group 6; woodland group 6)

Koloa Series

This series consists of well-drained soils on slopes of old volcanic vents and upland ridges on the island of Kauai. These soils are underlain by hard rock at a depth of 20 to 40 inches. They developed in material weathered from basic igneous rock. They are gently sloping to moderately steep. Elevations range from nearly sea level to 300 feet. The annual rainfall amounts to 40 to 60 inches. The mean annual soil temperature is 74° F. Koloa soils are geographically associated with Mamala and Waikomo soils.

These soils are used for irrigated sugarcane. The natural vegetation is mainly koa haole.

Koloa stony silty clay, 3 to 8 percent slopes (KvB).—This soil occurs on upland slopes. Included in mapping were small areas that are more than 40 inches deep.

In a representative profile the surface layer is dark reddish-brown stony silty clay about 7 inches thick. The

subsoil, about 13 inches thick, is dark-red and dark reddish-brown stony silty clay that has subangular blocky structure. The substratum is hard rock. The soil is slightly acid to neutral throughout the profile.

Permeability is moderately rapid. Runoff is slow, and the erosion hazard is slight. The available water capacity is about 1.8 inches per foot of soil. Roots penetrate to the bedrock.

Representative profile: Island of Kauai, lat. 21°53′5.6″ N. and long. 159°26′15″ W.

Ap—0 to 7 inches, dark reddish-brown (5YR 3/3) stony silty clay, weak red (2.5YR 4/2) when dry; strong, fine and very fine, subangular blocky structure; very hard, firm, sticky and plastic; abundant roots; 10 to 20 percent stones; violent effervescence with hydrogen peroxide; slightly acid; clear, smooth boundary. 5 to 7 inches thick.

B21—7 to 13 inches, dark reddish-brown (2.5YR 3/3) stony silty clay, dark reddish brown (2.5YR 3/4) when rubbed, dark reddish brown (5YR 3/3) when dry; weak, fine, subangular blocky structure; very hard, firm, sticky and plastic; plentiful roots; common fine pores; 10 to 20 percent stones; strong effervescence with hydrogen peroxide; patchy glaze on peds; some highly weathered pebbles; neutral; gradual, smooth boundary. 6 to 8 inches thick.

B22—13 to 20 inches, dark-red (2.5YR 3/5) stony silty clay, dark red (2.5YR 3/6) when dry; weak, fine and very fine, subangular blocky structure; pockets where structure is strong, very fine, subangular blocky; very hard, firm, very sticky and plastic; plentiful roots; many fine pores; 15 to 30 percent stones; moderate effervescence with hydrogen peroxide; continuous pressure cutans; many highly weathered pebbles; black coatings inside pebbles; neutral; abrupt, irregular boundary. 7 to 10 inches thick.

R—20 inches, hard pahoehoe rock that has a thin, weathered crust; vesicles in rock have black coatings that effervesce with hydrogen peroxide.

The A horizon ranges from 2.5YR to 5YR in hue, from 3 to 4 in chroma, and from 2 to 3 in value. The B horizon ranges from 10R to 5YR in hue and from 3 to 5 in chroma. The depth to bedrock ranges from 20 to 25 inches.

This soil is used for sugarcane. (Capability classification IIe if irrigated, IVe if nonirrigated; sugarcane group 1; pasture group 5; woodland group 5)

Koloa stony silty clay, 8 to 15 percent slopes (KvC).—On this soil, runoff is medium and the erosion hazard is moderate.

This soil is used for irrigated sugarcane. (Capability classification IIIe if irrigated, IVe if nonirrigated; sugarcane group 1; pasture group 5; woodland group 5)

Koloa stony silty clay, 15 to 25 percent slopes (KvD).—On this soil, runoff is medium and the erosion hazard is moderate to severe. Included in mapping were small areas where the slope is more than 40 percent.

This soil is used for irrigated sugarcane, pasture, woodland, and wildlife habitat. (Capability classification IVe, irrigated or nonirrigated; sugarcane group 1; pasture group 5; woodland group 5)

Kolokolo Series

This series consists of well-drained soils on bottom lands on the island of Kauai. These soils developed in alluvium washed from upland soils. They are level to gently sloping. Elevations range from about 50 to 500 feet. The annual rainfall amounts to 60 to 150 inches. The mean annual soil temperature is 73° F. Kolokolo soils are geographically associated with Hanalei soils.

These soils are used for pasture and wildlife habitat. The natural vegetation consists of pangolagrass, kikuyugrass, guava, pandanus, paragrass, glenwoodgrass, ricegrass, hau, and mango.

Kolokolo clay loam (Kw).—This soil is on stream bottoms. The slope ranges from 0 to 2 percent.

In a representative profile the surface layer is very dark brown clay loam about 19 inches thick. The next layer is dark-brown, very dark grayish-brown, and brown loam to silty clay loam more than 41 inches thick. Below this is stratified alluvium. The soil is neutral throughout the profile.

Permeability is moderate. Runoff is very slow, and the erosion hazard is no more than slight. The available water capacity is about 1.8 inches per foot of soil. In places roots penetrate to a depth of 5 feet or more. This soil is subject to damaging overflow.

Representative profile: Island of Kauai, lat. 22°02′48″ N. and long. 159°21′38.7″ W.

A1—0 to 19 inches, very dark brown (10YR 2/3) clay loam, dark brown (10YR 3/3) when dry; moderate, fine, subangular blocky structure; very hard, friable, sticky and plastic; plentiful fine, very fine, and micro roots; slight effervescence with hydrogen peroxide; few pebbles; neutral; abrupt, irregular boundary. 16 to 23 inches thick.

C1—19 to 28 inches, dark-brown (7.5YR 3/2) loam, brown (7.5YR 4/4) when dry; massive; slightly hard, friable, slightly sticky and plastic; plentiful fine and very fine roots; many medium, fine, and very fine pores; slight effervescence with hydrogen peroxide; material looks sandy until rubbed; many worm casts of dark material from A1 horizon; few pebbles; neutral; clear, smooth boundary. 6 to 11 inches thick.

C2—28 to 46 inches, very dark grayish-brown (10YR 3/2) silty clay loam, dark grayish brown (10YR 4/2) when dry; weak, fine, subangular blocky structure; slightly hard, friable, sticky and plastic; few fine and very fine roots; many medium, fine, and very fine pores; slight effervescence with hydrogen peroxide; few pebbles; neutral; gradual, smooth boundary. 16 to 20 inches thick.

C3—46 to 60 inches, brown (10YR 4/3), moist and dry, silty clay loam; weak, fine, subangular blocky structure; hard, friable, sticky and plastic; few fine and very fine roots; many fine and very fine pores; slight effervescence with hydrogen peroxide; material looks sandy until rubbed; common black stains; few pebbles; neutral.

In places the A horizon is loam. It ranges from 7.5YR to 10YR in hue and from 2 to 3 in chroma and value. The C horizon ranges from 7.5YR to 10YR in hue, from 2 to 3 in chroma, and from 3 to 4 in value.

This soil is used for pasture. (Capability classification IIw, irrigated or nonirrigated; pasture group 8; woodland group 7)

Kolokolo extremely stony clay loam (KUL).—This soil is similar to Kolokolo clay loam, except that it is extremely stony. The stones and boulders make cultivation impractical. The soil is subject to damaging overflow. Included in mapping were some extremely bouldery areas and some areas where the slope is as much as 12 percent.

This soil is used for pasture and wildlife habitat. (Capability classification VIIs, nonirrigated; pasture group 8; woodland group 7)

Koolau Series

This series consists of poorly drained soils on uplands on the island of Kauai. These soils developed in material weathered from basic igneous rock. They are nearly level to moderately steep. Elevations range from 750 to 5,200 feet. The annual rainfall amounts to 120 to 200 inches. The mean annual soil temperature is 62° F. Koolau soils are geographically associated with Pooku and Alakai soils.

These soils are used for water supply and wildlife habitat. A small area is used for pasture and sugarcane. The natural vegetation consists of false staghornfern, melastoma, ohia, treefern, lacefern, guava, lantana, glenwoodgrass, ricegrass, and hilograss.

Koolau silty clay, 0 to 8 percent slopes (KVSB).—This soil is on upland ridges.

In a representative profile the surface layer is mottled light brownish-gray and gray silty clay about 11 inches thick. The subsoil, 21 inches thick, is mottled pale-yellow and gray silty clay. The substratum is mottled light olive-brown clay loam. The soil is very strongly acid to extremely acid throughout the profile.

Permeability is rapid above the substratum and moderately slow in the substratum. Runoff is slow, and the erosion hazard is no more than slight. Roots penetrate to a depth of about 24 inches.

Representative profile: Island of Kauai, lat. 22°09′47.6″ N. and long. 159°27′42.4″ W.

O1—2 inches to 0, undecomposed leaves and stems of uluhe-fern.

A11—0 to 7 inches, coarsely mottled, light brownish-gray (2.5YR 6/2 and 10YR 6/2) silty clay, light gray (2.5Y 7/1) when dry; brown stains in root channels; massive; very hard, firm, sticky and plastic; abundant roots; extremely acid; abrupt, smooth boundary. 6 to 8 inches thick.

A12—7 to 11 inches, gray (2.5Y 5/1) silty clay, light gray (10YR 7/1) when dry; coarse mottles of yellow (10YR 7/6) and coatings of brown (10YR 5/3) in pores; massive; very hard, very firm, sticky and plastic; few roots; many medium wormholes; many fine and very fine pores; extremely acid; abrupt, smooth boundary. 4 to 6 inches thick.

B21—11 to 23 inches, pale-yellow (5Y 7/3) silty clay, white (5Y 8/1) when dry; coarsely mottled with light yellowish brown (10YR 6/4) and strong brown (7.5YR 5/6); weak, fine, subangular blocky structure; very hard, firm, sticky and plastic; few roots; many medium, fine, and very fine pores; very strongly acid; gradual, smooth boundary. 10 to 14 inches thick.

B22g—23 to 27 inches, gray (N 5/0) light silty clay, light gray (5Y 7/2) when dry; mottled with very pale brown (10YR 7/3), yellow (10YR 7/6), and strong brown (7.5YR 5/8); coatings of light brown (7.5YR 6/4) in some pores; massive, but exhibits horizontal lenses that are very firm; hard, friable, sticky and plastic, and weakly smeary; no roots; many medium, fine, and very fine pores; thin, patchy coatings in pores; coatings look like clay films; extremely acid; gradual, smooth boundary. 3 to 6 inches thick.

B23g—27 to 32 inches, gray (5Y 5/1) clay loam, pale yellow (5Y 7/3) when dry; mottles of yellowish brown (10YR 5/6), light olive brown (2.5YR 5/4), red (2.5YR 4/8), and brown (10YR 4/3); coatings of very pale brown (10YR 7/3); weak, thick, platy structure breaking to weak, fine, angular and subangular blocky; slightly hard, friable, sticky and plastic, and smeary; no roots; few medium pores and many fine and very fine pores; moderately thick coatings in some pores; coatings look like clay films; very strongly acid; clear, smooth boundary. 4 to 6 inches thick.

C—32 to 60 inches, light olive-brown (2.5Y 5/4) clay loam, brownish yellow (10YR 6/6) when dry; coatings and horizontal bands of very pale brown (10YR 7/4), brown (7.5YR 5/4), dark grayish brown (10YR 4/2), dark red (2.5YR 3/6), and dark reddish brown (5YR 3/3); thin (1/8 inch thick), hard, discontinuous bands of ironstone; weak, medium, platy structure; hard, very firm, sticky and plastic; no roots; no pores; thin coatings between plates; very strongly acid.

The A horizon ranges from 1 to 2 in chroma and from 4 to 6 in value. Mottles in the A horizon range from none to many. The B horizon ranges from 5Y to 10YR in hue, from 0 to 3 in chroma, and from 4 to 7 in value. The water table is at a depth of 2 to 4 feet.

This soil is used mostly for water supply and wildlife habitat. A small acreage is used for pasture and sugarcane. (Capability classification VIw, nonirrigated; pasture group 11; woodland group 16)

Koolau silty clay, 8 to 30 percent slopes (KVSE).—On this soil, runoff is medium and the erosion hazard is slight to moderate.

This soil is used for water supply and wildlife habitat. (Capability classification VIw, nonirrigated; pasture group 11; woodland group 16)

Kula Series

This series consists of well-drained soils on uplands on the island of Maui. These soils developed in volcanic ash. They are gently sloping to steep. Elevations range from 2,000 to 3,500 feet. The annual rainfall amounts to 25 to 40 inches. The mean annual soil temperature is 66° F. Kula soils are geographically associated with Kaipoioi, Kamaole, and Pane soils.

These soils are used for pasture, truck crops, orchard crops, and wildlife habitat. The natural vegetation consists of bermudagrass, black wattle, Natal redtop, oi, rattailgrass, and yellow foxtail.

Kula cobbly loam, 12 to 20 percent slopes (KxaD).—This soil is on intermediate uplands. Included in mapping were small areas of Kaipoioi and Kamaole soils. Also included were small areas of gently sloping soils.

In a representative profile the surface layer is dark reddish-brown loam about 8 inches thick. The subsoil, about 46 inches thick, is dark reddish-brown loam, silt loam, and silty clay loam that has subangular blocky structure. The substratum is slightly weathered basic igneous rock. The soil is slightly acid in the surface layer and slightly acid to neutral in the subsoil.

Permeability is moderately rapid. Runoff is medium, and the erosion hazard is moderate. The available water capacity is about 1.8 inches per foot of soil. In places roots penetrate to rock.

Representative profile: Island of Maui, lat. 20°45′40″ N. and long. 156°19′22″ W.

A1—0 to 8 inches, dark reddish-brown (5YR 3/2) cobbly loam, dark reddish brown (5YR 3/4) when dry; weak, fine, granular structure; soft, friable, nonsticky and nonplastic; abundant fine roots; many medium pores; many very small, red and black particles visible under hand lens; slight effervescence with hydrogen peroxide; slightly acid; clear, smooth boundary. 7 to 10 inches thick.

B21—8 to 19 inches, dark reddish-brown (5YR 3/2) loam, dark reddish brown (5YR 3/4) when dry; moderate, medium, subangular blocky structure; soft, friable, slightly sticky and slightly plastic; abundant fine roots; many medium pores; slightly acid; gradual, wavy boundary. 8 to 13 inches thick.

B22—19 to 30 inches, dark reddish-brown (5YR 3/3) silt loam, reddish brown (5YR 4/4) when dry; moderate, coarse, subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; abundant fine roots; many medium and coarse pores; neutral; abrupt, irregular boundary. 10 to 12 inches thick.

IIB23b—30 to 42 inches, dark reddish-brown (5YR 3/3) silty clay loam, dark reddish brown (5YR 3/4) when dry; strong, fine, subangular blocky structure; hard, friable, slightly sticky and slightly plastic; abundant fine roots; many fine and medium pores; nearly continuous, gelatinlike coatings on peds; many sand-size aggregates that are resistant to crushing; common worm casts 10 to 15 millimeters in size; many very fine roots matted along surfaces of worm casts; neutral; clear, wavy boundary. 10 to 13 inches thick.

IIB3b—42 to 54 inches, dark reddish-brown (5YR 3/2) silty clay loam, reddish brown (5YR 4/4) when dry; strong, fine, subangular blocky structure; hard, friable, slightly sticky and slightly plastic; plentiful fine roots and many fine and medium pores; 30 to 40 percent weathered andesite and basalt fragments; neutral; clear, wavy boundary. 10 to 14 inches thick.

IICb—54 inches, weathered andesite and basalt that has thin seams of soil material in cracks.

The depth to slightly weathered andesite and basalt ranges from 45 to 62 inches. In some places rock outcrop occupies 0.1 to 3 percent of the surface. The A horizon ranges from 5YR to 10YR in hue, from 2 to 3 in value when moist and 3 to 4 when dry, and from 2 to 3 in chroma when moist and 2 to 4 when dry. The B horizon ranges from 5YR to 10YR in hue, from 3 to 4 in value when moist or dry, and from 2 to 4 in chroma when moist. The B horizon ranges from loam to silty clay loam in texture. The IIB horizon has strong to moderate subangular blocky structure.

This soil is used for pasture. Small areas are used for truck and orchard crops. Most of the cobblestones have been removed in areas where truck crops are grown. (Capability classification IVe, irrigated or nonirrigated; pasture group 4; woodland group 2)

Kula loam, 4 to 12 percent slopes (KxC).—This soil has a profile like that of Kula cobbly loam, 12 to 20 percent slopes, except that it is nearly free of cobblestones.

This soil is used for truck crops and pasture. (Capability classification IIIe, irrigated or nonirrigated; pasture group 4; woodland group 2)

Kula loam, 12 to 20 percent slopes (KxD).—This soil has a profile like that of Kula cobbly loam, 12 to 20 percent slopes, except that it is nearly free of cobblestones. Included in mapping were small, stony areas and a few rock outcrops, mainly on knolls and the sides of small gulches.

This soil is used for pasture and truck crops. (Capability classification IVe, irrigated or nonirrigated; pasture group 4; woodland group 2)

Kula very rocky loam, 12 to 40 percent slopes (KxbE).—This soil has a profile like that of Kula cobbly loam, 12 to 20 percent slopes, except that rock outcrops cover 10 to 25 percent of the surface. Runoff is medium, and the erosion hazard is moderate.

This soil is used for pasture and wildlife habitat. (Capability classification VIs, nonirrigated; pasture group 4; woodland group 2)

Kunia Series

This series consists of well-drained soils on upland terraces and fans on the island of Oahu. These soils developed in old alluvium. They are nearly level to moderately sloping. Elevations range from 700 to 1,000 feet. The mean annual rainfall amounts to 30 to 40 inches, most of which occurs from November to April. The mean annual soil temperature is 71° F. Kunia soils occur on the foot slopes of the Waianae Range, near Schofield Barracks. They are geographically associated with Kolekole, Lahaina, and Wahiawa soils.

These soils are used for sugarcane, pineapple, homesites, and military reservations. Most areas are cultivated, and the natural vegetation is not significant.

Kunia silty clay, 0 to 3 percent slopes (KyA).—This soil occurs on broad, smooth slopes. Included in mapping were small areas of Kolekole soils and small areas of red, clayey soils at lower elevations.

In a representative profile the surface layer is dark reddish-brown silty clay about 22 inches thick. The subsoil, 40 to 71 inches thick, is dark reddish-brown silty clay and silty clay loam that has subangular blocky structure. The substratum is dark reddish-brown gravelly silty clay. Manganese concretions occur throughout the profile. The surface layer is medium acid to extremely acid, and the subsoil is slightly acid to strongly acid.

Permeability is moderate. Runoff is slow, and the erosion hazard is no more than slight. The available water capacity is about 1.7 inches per foot of soil. In places roots penetrate to a depth of 5 feet or more.

Representative profile: Island of Oahu, lat. 21°28′42″ N. and long. 158°03′43″ W.

Ap1—0 to 3 inches, dark reddish-brown (5YR 2/2) silty clay, dark reddish brown (5YR 3/3) when dry; moderate, fine and very fine, granular structure; hard, friable, sticky and plastic; abundant roots; many fine and very fine, interstitial pores; strong effervescence with hydrogen peroxide; extremely acid; clear, wavy boundary. 2 to 9 inches thick.

Ap2—3 to 22 inches, dark reddish-brown (5YR 2/2) silty clay, dark reddish brown (5YR 3/3) when dry; weak, fine and medium, subangular blocky structure; hard, firm, sticky and plastic; few fine roots; common, very fine, tubular and interstitial pores; compacted by tillage; few, fine and very fine, black concretions; few charcoal specks; strong effervescence with hydrogen peroxide; extremely acid; abrupt, smooth boundary. 9 to 19 inches thick.

B1—22 to 29 inches, dark reddish-brown (2.5YR 3/4) silty clay, dark reddish brown (2.5YR 2/4) when moist; weak, fine and medium, subangular blocky structure; slightly hard, firm, sticky, and plastic; no roots; common, very fine, tubular pores; few, patchy pressure cutans; few, fine and very fine, black concretions; strongly acid; clear, wavy boundary. 5 to 18 inches thick.

B2—29 to 47 inches, dark reddish-brown (2.5YR 2/4) silty clay, dark reddish brown (2.5YR 3/4) when dry; moderate, very fine and fine, subangular blocky structure; slightly hard, firm, sticky and plastic; no roots; common, fine, tubular pores; weak, patchy pressure cutans; few black concretions; slight effervescence with hydrogen peroxide on soil mass but strong on the black concretions; slightly acid; clear, wavy boundary. 8 to 36 inches thick.

B3—47 to 74 inches, dark reddish-brown (2.5YR 3/6) silty clay loam, dark red (2.5YR 3/4) when moist; moderate, medium, blocky structure breaking to moderate, fine, subangular blocky; hard, firm, sticky and

plastic; few, very fine, tubular pores coated with black stains; strong, continuous pressure cutans; few hard rock cores; few worm casts; very slight effervescence with hydrogen peroxide on soil mass; few, fine, black concretions that show moderate effervescence with hydrogen peroxide; medium acid.

In places this soil is underlain by gravelly alluvium below a depth of 4 feet, particularly where the alluvial fans have been dissected by drainageways. The Ap horizon ranges from 5YR to 2.5YR in hue and from 3 to 4 in value when dry. The B horizon ranges from 3 to 6 in chroma when dry. The B3 horizon ranges from silty clay to silty clay loam.

This soil is used for sugarcane, pineapple, homesites, and military reservations. (Capability classification I if irrigated, IIIc if nonirrigated; sugarcane group 1; pineapple group 1; pasture group 3; woodland group 1)

Kunia silty clay, 3 to 8 percent slopes (KyB).—On this soil, runoff is slow and the erosion hazard is slight. Included in mapping were small areas of nearly level soils and small areas of Kolekole soils.

This soil is used for sugarcane, pineapple, and homesites. (Capability classification IIe if irrigated, IIIc if nonirrigated; sugarcane group 1; pineapple group 2; pasture group 3; woodland group 1)

Kunia silty clay, 8 to 15 percent slopes (KyC).—This soil occurs on narrow side slopes, mainly along drainageways. Runoff is medium, and the erosion hazard is moderate. Included in mapping were small, eroded areas.

This soil is used for sugarcane, pineapple, and homesites. (Capability classification IIIe, irrigated or nonirrigated; sugarcane group 1; pineapple group 3; pasture group 3; woodland group 1)

Kunuweia Series

This series consists of well-drained, very gravelly soils on ridgetops on the island of Kauai. These soils developed in material weathered from basic igneous rock. They are nearly level to strongly sloping. Elevations range from 3,500 to 4,000 feet. The annual rainfall amounts to 70 to 150 inches. The mean annual soil temperature is 58° F. Kunuweia soils are geographically associated with Kokee soils.

These soils are used for water supply, wildlife habitat, and woodland. The natural vegetation consists of ohia, koa, redwood, blackwood, blackberry, mokihana, olopua, maile, hilograss, ricegrass, uki, uki uki, and ferns.

Kunuweia very gravelly clay loam, 0 to 15 percent slopes (KZC).—This soil is on the tops of ridges in the uplands. Included in mapping were a few areas where the slope is up to 30 percent. Also included was an area, southeast of Kalihiwai reservoir, that is at a lower elevation and is poorly drained.

In a representative profile the surface layer is dark-brown very gravelly clay loam about 12 inches thick. The subsoil, more than 36 inches thick, is yellowish-brown, light yellowish-brown, and dark reddish-brown, massive clay loam. It contains thin, discontinuous ironstone seams and thin, scalelike fragments of ironstone. The substratum is soft, weathered rock. The soil is very strongly acid throughout.

Permeability is moderately rapid. Runoff is slow, and the erosion hazard is slight. Root penetration is limited to the A horizon and the soft material in the B2ir horizon.

Representative profile: Island of Kauai, lat. 22°08′8.4″ N. and long. 159°38′28″ W.

A1—0 to 12 inches, dark-brown (10YR 4/3) very gravelly clay loam, brown (7.5YR 5/2) when dry; strong, fine and very fine, granular structure; loose, friable, sticky and slightly plastic; abundant roots; moderate, delayed effervescence with hydrogen peroxide; gravel consists of ironstone pebbles, mostly smooth; few pieces of ironstone, up to 10 inches across, scattered over the surface and in the A1 horizon; very strongly acid; abrupt, smooth boundary. 11 to 14 inches thick.

B2ir—12 to 60 inches, plinthite that has ¼- to 1-inch seams of extremely hard, very dusky red (2.5YR 2/2) ironstone; yellowish-brown (10YR 5/4), light yellowish-brown (10YR 6/4), and dark reddish-brown (5YR 3/4) clay loam, reddish yellow (7.5YR 6/6) when dry; massive; slightly hard, friable, slightly sticky and plastic, and smeary; few fine and very fine roots. In the upper 12 inches of this horizon, the seams are numerous and appear to be not oriented; below 12 inches, they are few and appear to encircle older boulder cores.

The A horizon has a purplish cast in some areas. In some places there is a thin mat of very dark brown to black organic matter, humus, and roots on the surface. On the surface and in the A horizon are chunks of extremely hard ironstone.

This soil is used for water supply, wildlife habitat, and woodland. (Capability classification VIs, nonirrigated; pasture group 12; woodland group 12)

Lahaina Series

This series consists of well-drained soils on uplands on the islands of Lanai, Maui, Molokai, and Oahu. These soils developed in material weathered from basic igneous rock. They are nearly level to steep. Elevations range from 10 to 1,500 feet. The annual rainfall amounts to 20 to 35 inches, most of which occurs in fall and winter. The mean annual soil temperature is 72° F. Lahaina soils are geographically associated with Helemano, Hoolehua, Kahana, Molokai, Pamoa, and Wahiawa soils.

These soils are used for sugarcane and pineapple. Small acreages are used for truck crops, pasture, homesites, and wildlife habitat. The natural vegetation consists of bermudagrass, feather fingergrass, ilima, kiawe, lantana, oi, and uhaloa.

Lahaina silty clay, 3 to 7 percent slopes (LcB).—This soil is on smooth uplands. Included in mapping were small areas that are underlain by consolidated sand at a depth below 30 inches. Cobblestones are common on the surface in a few places. In some places, near the coastal plains, the profile contains fragments of coral, stones, gravel, or sand.

In a representative profile the surface layer is dark reddish-brown, silty clay about 15 inches thick. The subsoil, about 45 inches thick, is dusky-red and dark reddish-brown subangular blocky silty clay and silty clay loam. The substratum is soft, weathered basic igneous rock. These soils are medium acid in the surface layer and slightly acid to medium acid in the subsoil.

Permeability is moderate. Runoff is slow, and the erosion hazard is slight. The available water capacity is about 1.3 inches per foot in the surface layer and about 1.4 inches per foot in the subsoil. In places roots penetrate to a depth of 5 feet or more.

Representative profile: Island of Maui, lat. 20°55'28" N. and long. 156°40'27" W.

Ap1—0 to 7 inches, dark reddish-brown (2.5YR 3/4) silty clay, dark reddish brown (2.5YR 3/4) when dry; weak, fine to coarse, granular structure; hard, friable, very sticky and very plastic; abundant roots; many fine and very fine pores; many black concretions (1 to 3 millimeters) that effervesce with hydrogen peroxide; common, small, earthy lumps that break down on persistent rubbing; strong effervescence with hydrogen peroxide; medium acid; abrupt, wavy boundary. 6 to 9 inches thick.

Ap2—7 to 15 inches, dark reddish-brown (2.5YR 3/4) silty clay, dark reddish brown (2.5YR 3/4) when dry; weak, medium and coarse, subangular blocky structure; hard, friable, very sticky and very plastic; abundant roots; few medium and fine pores; compacted by machinery; many black concretions (1 to 3 millimeters) that effervesce with hydrogen peroxide; violent effervescence with hydrogen peroxide; medium acid; abrupt, wavy boundary. 6 to 9 inches thick.

B1—15 to 23 inches, dusky-red (10R 3/3) silty clay, dark reddish brown (2.5YR 3/4) when dry; weak, medium and coarse, subangular blocky structure; hard, friable, very sticky and very plastic; abundant roots; many fine and very fine pores; many black concretions (1 to 3 millimeters) that effervesce with hydrogen peroxide; violent effervescence with hydrogen peroxide; slightly acid; gradual, wavy boundary. 4 to 10 inches thick.

B21—23 to 31 inches, dusky-red (10R 3/3) silty clay, dusky red (10R 3/4) when dry; moderate, medium and coarse, subangular blocky structure; hard, friable, sticky and plastic; plentiful roots; many fine and very fine pores; nearly continuous pressure cutans on ped surfaces; many black concretions (1 to 3 millimeters) that effervesce with hydrogen peroxide; violent effervescence with hydrogen peroxide; medium acid; gradual, wavy boundary. 6 to 15 inches thick.

B22—31 to 46 inches, dark reddish-brown (2.5YR 3/4) heavy silty clay loam, dark red (2.5YR 3/6) when dry; moderate, medium, subangular blocky structure in place, breaking to moderate, very fine, subangular blocky when disturbed; hard, friable, sticky and plastic; very few roots; many medium and fine pores; very compact in place; nearly continuous pressure cutans on ped surfaces; few weathered basalt stones and boulders; many black concretions (1 to 3 millimeters) that effervesce with hydrogen peroxide; slight effervescence with hydrogen peroxide; slightly acid; gradual, wavy boundary. 10 to 18 inches thick.

B3—46 to 60 inches, dark reddish-brown (2.5YR 3/4) heavy silty clay loam, dark red (2.5YR 3/6) when dry; strong, medium and coarse, subangular blocky structure; hard, friable, sticky and plastic; many fine pores; many, small, patchy pressure cutans on ped faces; common black concretions (1 to 3 millimeters) that effervesce with hydrogen peroxide; many strongly weathered basalt particles (¼ millimeter to 2 millimeters); common, weathered basalt stones; slight effervescence with hydrogen peroxide; medium acid.

The solum ranges from 36 to more than 60 inches in thickness. The A horizon ranges from 5YR to 10R in hue, and from 3 to 4 in chroma when moist and 3 to 6 when dry. The B horizon ranges from 2.5YR to 10R in hue and from 3 to 4 in chroma when moist and 3 to 6 when dry.

This soil is used for sugarcane and pineapple. Small acreages are used for truck crops, pasture, and homesites. (Capability classification IIe if irrigated, IIIc if nonirrigated; sugarcane group 1; pineapple group 2; pasture group 3; woodland group 1)

Lahaina silty clay, 0 to 3 percent slopes (LaA).—On this soil runoff is slow and the erosion hazard is no more than slight.

This soil is used for sugarcane and pineapple. (Capability classification I if irrigated, IIIc if nonirrigated; sugarcane group 1; pineapple group 1; pasture group 3; woodland group 1)

Lahaina silty clay, 3 to 7 percent slopes, severely eroded (LaB3).—This soil has a profile like that of Lahaina silty clay, 3 to 7 percent slopes, except that most of the surface layer and, in places, part of the subsoil have been removed by erosion. A few areas are eroded to soft, weathered rock. In places there are small dunes formed by winddrifted soil material. Blown-out spots occur between the dunes. The erosion hazard is moderate to severe. Included in mapping were small, nearly level areas.

This soil is used for pasture and wildlife habitat. (Capability classification IIIe if irrigated, IVe if nonirrigated; sugarcane group 1; pineapple group 2; pasture group 3; woodland group 1)

Lahaina silty clay, 7 to 15 percent slopes (LaC).—On this soil, runoff is medium and the erosion hazard is moderate. Included in mapping were small, steep areas and areas where a few cobblestones and stones are on the surface.

This soil is used for sugarcane and pineapple. Small acreages are used for truck crops, pasture, and wildlife habitat. (Capability classification IIIe, irrigated or nonirrigated; sugarcane group 1; pineapple group 3; pasture group 3; woodland group 1)

Lahaina silty clay, 7 to 15 percent slopes, severely eroded (LaC3).—This soil has a profile like that of Lahaina silty clay, 3 to 7 percent slopes, except that most of the surface layer and, in places, part of the subsoil have been removed by erosion. Runoff is medium, and the erosion hazard is severe. Included in mapping were small blown-out spots and gullies and small, very stony areas that are eroded to weathered rock.

This soil is used for sugarcane and pineapple. (Capability classification IVe, irrigated or nonirrigated; sugarcane group 1; pineapple group 3; pasture group 3; woodland group 1)

Lahaina silty clay, 15 to 25 percent slopes (LaD).—On this soil, runoff is medium and the erosion hazard is moderate. Included in mapping were small areas where most of the surface layer and, in places, part of the subsoil have been removed by erosion.

This soil is used for sugarcane. (Capability classification IVe, irrigated or nonirrigated; sugarcane group 1; pineapple group 3; pasture group 3; woodland group 1)

Lahaina silty clay, 15 to 25 percent slopes, severely eroded (LaD3).—This soil has a profile like that of Lahaina silty clay, 3 to 7 percent slopes, except that most of the surface layer and, in places, part of the subsoil have been removed by erosion. Runoff is medium, and the erosion hazard is severe. Included in mapping were small areas that are eroded to soft, weathered rock.

This soil is used for pasture and wildlife habitat. (Capability classification VIe, irrigated or nonirrigated; pasture group 3; woodland group 1)

Lahaina silty clay, 25 to 40 percent slopes, severely eroded (LaE3).—This soil has a profile like that of Lahaina

silty clay, 3 to 7 percent slopes, except that most of the surface layer and, in places, part of the subsoil have been removed by erosion. Runoff is medium to rapid, and the erosion hazard is severe. Included in mapping were small, gently sloping areas and small areas that are eroded to weathered rock.

This soil is used for pasture and wildlife habitat. (Capability classification VIe, irrigated or nonirrigated; pasture group 3; woodland group 1)

Laumaia Series

This series consists of well-drained soils on the island of Maui. These soils developed in volcanic ash and cinders. They are moderately sloping to very steep. Elevations range from 5,500 to 8,000 feet. The annual rainfall amounts to 35 to 70 inches. These soils are subject to cloud cover or fog most of the year. The mean annual soil temperature is 53° F. Laumaia soils are geographically associated with Kaipoioi and Uma soils.

These soils are used for pasture and wildlife habitat. The natural vegetation consists of mamane, puakeawe, spear thistle, sweet vernalgrass, and Yorkshire foggrass.

Laumaia loam, 7 to 40 percent slopes (LME).—This soil is on complex, high mountain slopes. Included in mapping were small areas of Kaipoioi and Uma soils. Also included were small areas of eroded, extremely stony soils and rock outcrops.

In a representative profile, the surface layer is very dark brown or black loam about 9 inches thick. The subsoil, about 33 inches thick, is very dark brown silty clay loam and silt loam that has subangular blocky structure or is massive. The substratum consists of hard, cemented layers of volcanic ash and cinders interbedded with loamy soil material. The soil is mildly alkaline in the surface layer and neutral to medium acid in the subsoil.

Permeability is moderately rapid. Runoff is slow to medium, and the erosion hazard is slight to moderate. In places roots penetrate to a depth of 3 feet or more.

Representative profile: Island of Maui, lat. 20°42′56″ N. and long. 156°18′16″ W.

A1—0 to 9 inches, black (10YR 2/1) loam, very dark brown (10YR 2/2) when dry; moderate, medium and fine, granular structure; soft, very friable, nonsticky and nonplastic, and weakly smeary; abundant fine and very fine roots; many fine pores; many fine, gritty particles and highly weathered cinders; weak effervescence with hydrogen peroxide; mildly alkaline; clear, wavy boundary. 8 to 11 inches thick.

B21—9 to 15 inches, very dark brown (10YR 2/2) silty clay loam, dark brown (10YR 3/3) when dry; moderate, medium, subangular blocky structure; soft, friable, slightly sticky and slightly plastic, and weakly smeary; abundant fine and very fine roots; many fine pores; patchy, gelatinous coatings on peds; weak effervescence with hydrogen peroxide; neutral; clear, wavy boundary. 5 to 7 inches thick.

B22—15 to 24 inches, very dark brown (10YR 2/2) silty clay loam, dark yellowish brown (10YR 3/4) when dry; moderate, medium, subangular blocky structure; soft, friable, slightly sticky and slightly plastic, and weakly smeary; abundant fine roots; many fine pores; patchy, gelatinous coatings on peds; few highly weathered cinders less than 1 millimeter in diameter; neutral; clear, wavy boundary. 6 to 12 inches thick.

B23—24 to 32 inches, very dark brown (10YR 2/2) silt loam, dark yellowish brown (10YR 3/4) when dry; weak, coarse, subangular blocky structure; soft, very friable, slightly sticky and slightly plastic and weakly smeary; abundant fine roots; many fine and medium pores; few root channels ½ inch in diameter; neutral; clear, wavy boundary. 7 to 10 inches thick.

B3—32 to 42 inches, very dark brown (10YR 2/2) silt loam, dark yellowish brown (10YR 3/4) when dry; massive; soft, friable, slightly sticky and slightly plastic and weakly smeary; abundant very fine roots; many fine pores; many very highly weathered cinders; neutral; abrupt, wavy boundary. 9 to 11 inches thick.

IICm—42 to 51 inches, dark yellowish-brown (10YR 3/4) volcanic ash and cinders, light yellowish brown (10YR 6/4) when dry; hard and strongly cemented; abrupt, smooth boundary. 8 to 12 inches thick.

IIIAb—51 inches, very dark grayish-brown (10YR 3/2) gritty silt loam, brown (10YR 4/3) when dry; massive; soft, very friable, nonsticky and nonplastic; below this horizon are alternate layers of cemented ash and cinders and buried, moderately smeary bands of silt loam, to a depth of 4 to more than 7 feet.

The depth to ash and cinders is more than 40 inches. The A horizon ranges from 2 to 3 in value when moist or dry and from 1 to 2 in chroma when moist. The B horizon ranges from 5YR to 10YR in hue, from 2 to 3 in value when moist, and from 1 to 3 in chroma when moist. The texture is silty clay loam or silt loam.

These soils are used for pasture and wildlife habitat. (Capability classification VIe, nonirrigated; pasture group 13; woodland group 11)

Laumaia loam, 40 to 70 percent slopes (LMF).—On this soil, runoff is medium and the erosion hazard is moderate. Included in mapping were small areas of shallow soils on local cinder cones.

This soil is used for pasture and wildlife habitat. (Capability classification VIIe, nonirrigated; pasture group 13; woodland group 11)

Laumaia extremely stony loam, 7 to 40 percent slopes (LNE).—This soil has a profile like that of Laumaia loam, 7 to 40 percent slopes, except that stones cover 3 to 15 percent of the surface. Included in mapping were small, very steep areas and areas dissected by small drainageways.

This soil is used for pasture and wildlife habitat. (Capability classification VIIs, nonirrigated; pasture group 13; woodland group 11)

Lava Flows, Aa

Lava flows, Aa (rLW) consists of areas of geologically recent lava flows on the island of Maui. The flows are a mass of clinkery, hard, glassy, sharp pieces of lava on rough to undulating topography. The areas are difficult to traverse. Elevations range from nearly sea level to 8,000 feet. The annual rainfall amounts to 20 to 75 inches.

This miscellaneous land type is used for water supply, wildlife habitat, and recreation. Vegetation is limited to lichens, a few grasses, herbs, shrubs, and scrubby trees. (Capability classification VIIIs, nonirrigated)

Lawai Series

This series consists of moderately well drained to somewhat poorly drained soils at the base of hills on the island of Kauai. These soils developed in alluvium and in colluvial material. They are nearly level to moderately

steep. Elevations range from 500 to 800 feet. The annual rainfall amounts to 80 to 150 inches. The mean annual soil temperature is 72° F. Lawai soils are geographically associated with Halii and Hihimanu soils.

These soils are used for sugarcane. Prior to the closing of two canneries on the island, much of this soil was used for pineapple. The natural vegetation consists of guava, joee, melastoma, sensitiveplant, hilograss, and ricegrass.

Lawai silty clay, 0 to 8 percent slopes (LcB).—This soil is on colluvial slopes, alluvial fans, and stream bottoms.

In a representative profile the surface layer is dark-brown and very dark grayish-brown silty clay about 14 inches thick. The subsoil, more than 48 inches thick, is brown to dark-brown silty clay that has subangular and angular blocky structure. The substratum is clayey alluvium and colluvium. The surface layer is medium acid to strongly acid. The subsoil is medium acid.

Permeability is moderate to moderately rapid. Runoff is slow, and the erosion hazard is no more than slight. In places roots penetrate to a depth of 5 feet or more.

Representative profile: Island of Kauai, lat. 21°57′26.2″ N. and long. 159°27′35.5″ W.

Ap1—0 to 8 inches, very dark grayish-brown (10YR 3/2) silty clay, very dark grayish brown (10YR 3/2) when dry; weak, fine and very fine, subangular blocky structure; very hard, friable, sticky and plastic; abundant very fine, fine, and medium roots; many, fine and very fine, interstitial pores; common very fine, fine, and medium, tubular pores; about 40 percent of the material is from the Ap2 horizon, mixed by tillage; strongly acid; clear, broken boundary. 6 to 10 inches thick.

Ap2—8 to 14 inches, dark-brown (7.5YR 4/4) silty clay, dark brown (7.5YR 3/2) when dry; weak, very fine, subangular blocky structure; very hard, firm, sticky and plastic; abundant micro, very fine, fine, and medium roots; plentiful, micro and very fine, tubular pores; many, very fine, interstitial pores; weak, nearly continuous pressure cutans; about 20 percent of the material is from the Ap1 horizon, mixed by tillage; medium acid; clear, wavy boundary. 5 to 8 inches thick.

B21—14 to 26 inches, dark-brown (7.5YR 4/4) silty clay, dark brown (7.5YR 3/2) when dry; weak, fine and very fine, subangular blocky structure; very hard, firm, sticky and plastic; abundant micro, very fine, fine, and medium roots; common micro and very fine, tubular pores; many, very fine, interstitial pores; weak, nearly continuous pressure cutans; some yellowish, sugarlike granules in pores and on ped faces; medium acid; gradual, smooth boundary. 10 to 14 inches thick.

B22—26 to 42 inches, dark-brown (7.5YR 3/4) silty clay, dark brown (7.5YR 3/2) when dry; moderate, coarse, angular blocky structure with horizontal cleavage planes that give the appearance of lamination; breaks to very fine and fine, subangular blocky structure; very hard, firm, sticky and plastic; very few micro roots; nearly continuous pressure cutans; few higher chroma, sugarlike granules and light-red coatings in pores; few fine, yellowish-white concretions; less than 5 percent weathered rock; medium acid; gradual, smooth boundary. 14 to 18 inches thick.

B23—42 to 53 inches, dark-brown (7.5YR 3/3) silty clay, dark brown (7.5YR 3/4) when rubbed, dark brown (10YR 3/3) when dry; coatings in pores have a higher chroma; moderate, fine and very fine, angular and subangular blocky structure; very hard, firm, sticky and plastic; no roots; common micro and very fine, tubular pores; continuous pressure cutans; higher chroma, sugarlike granules on ped faces; light-red coatings around some old pebbles; about 5 percent weathered rock; medium acid; gradual, smooth boundary. 9 to 13 inches thick.

B24—53 to 60 inches, dark-brown (7.5YR 3/4) silty clay, brown (7.5YR 4/2) when dry; moderate, coarse to very fine, angular and subangular blocky structure; hard, firm, sticky and plastic; no roots; few micro, very fine, and fine, tubular pores; continuous pressure cutans; coatings of dark brown (10YR 4/3) on some large ped faces; higher chroma, sugarlike granules in some pores and on some ped faces; few, very fine, yellowish-white concretions; about 5 percent weathered rock; medium acid.

The A horizon ranges from 7.5YR to 2.5Y in hue, from 3 to 4 in value, and from 1 to 4 in chroma. The B horizon ranges from 2 to 4 in value and from 2 to 4 in chroma.

This soil is used for sugarcane. (Capability classification IIIw, nonirrigated; sugarcane group 2; pasture group 8; woodland group 7)

Lawai silty clay, 8 to 15 percent slopes (LcC).—On this soil, runoff is medium and the erosion hazard is slight to moderate.

This soil is used for sugarcane. (Capability classification IIIe, nonirrigated; sugarcane group 2; pasture group 8; woodland group 7)

Lawai silty clay, 15 to 25 percent slopes (LcD).—On this soil, runoff is medium and the erosion hazard is moderate. Included in mapping were small areas where the slope is as much as 40 percent.

This soil is used for sugarcane, pasture, water supply, and wildlife habitat. (Capability classification IVe, nonirrigated; sugarcane group 2; pasture group 8; woodland group 7)

Leilehua Series

This series consists of well-drained soils on uplands on the island of Oahu. These soils developed in material weathered from basic igneous rock. They are gently sloping to moderately sloping. Elevations range from 900 to 1,200 feet. The annual rainfall amounts to 60 to 80 inches and is fairly well distributed throughout the year. The mean annual soil temperature is 70° F. Leilehua soils are geographically associated with Manana, Paaloa, and Wahiawa soils.

These soils are used for sugarcane, pineapple, and pasture. The natural vegetation consists of guava, Formosa koa, eucalyptus, and bermudagrass.

Leilehua silty clay, 2 to 6 percent slopes (LeB).—This soil occurs as broad areas, as well as narrow areas bordered by gulches. Included in mapping were small areas of Manana soils.

In a representative profile the surface layer is dark reddish-brown silty clay about 12 inches thick. It contains concentrations of heavy minerals. The subsoil, about 36 inches thick, is dark reddish-brown and dusky-red silty clay and clay that has subangular blocky structure. The substratum is dark reddish-brown clay mixed with weathered gravel. The soil is extremely acid throughout the profile.

Permeability is moderately rapid. Runoff is slow, and the erosion hazard is slight. The available water capacity is about 1.3 inches per foot of soil. Roots penetrate to a depth of 5 feet or more.

Representative profile: Island of Oahu, lat. 21°29′02″ N. and long. 157°59′40″ W.

Ap—0 to 12 inches, dark reddish-brown (5YR 3/3) silty clay, reddish brown (5YR 4/3) when dry; moderate, fine to coarse, granular structure; very hard, firm, sticky and very plastic; plentiful roots; common, very fine, interstitial pores and many, fine, interstitial pores; many very fine glistening specks; common, fine, gray particles presumed to be titanium oxide; few chunks and pockets of dusky-red material mixed by tillage from a lower horizon; decomposing pineapple trash throughout horizon; lower part of horizon contains 1-inch layer of pineapple trash; extremely acid; abrupt, smooth boundary. 6 to 12 inches thick.

B21—12 to 17 inches, dark reddish-brown (2.5YR 3/4), moist and dry, silty clay; few fragments and pockets of dusky-red material mixed by tillage; weak, medium and coarse, subangular blocky structure; hard, firm, sticky and plastic; plentiful roots; common, very fine and fine, tubular pores; many very fine glistening specks; common, fine, gray material presumed to be titanium oxide; compacted by tillage; extremely acid; abrupt, smooth boundary. 5 to 7 inches thick.

B22—17 to 22 inches, dark reddish-brown (2.5YR 3/4), moist and dry, silty clay; weak, coarse, subangular blocky structure breaking to moderate, very fine and fine, subangular blocky; hard, firm, sticky and plastic; few fine roots; many, very fine and fine, tubular pores; many very fine glistening specks; common fine fragments of gray material presumed to be titanium oxide; numerous, very firm, earthy lumps; extremely acid; abrupt, smooth boundary. 5 to 7 inches thick.

B23t—22 to 31 inches, dusky-red (10R 3/3) silty clay, dusky red (10R 3/4) when dry; weak, coarse and medium, subangular blocky structure; few pockets where structure is moderate, very fine, subangular blocky; hard, friable, sticky and very plastic; very few roots; many, very fine and fine, tubular pores and common, medium, tubular pores; thin, patchy clay films and weak pressure cutans on peds; extremely acid; clear, smooth boundary. 9 to 12 inches thick.

B24t—31 to 41 inches, dark reddish-brown (2.5YR 3/4, 3/3 when crushed) clay, dark reddish brown (2.5YR 4/4) when dry; weak, coarse, subangular blocky structure breaking to moderate, very fine and fine, subangular blocky; hard, firm, sticky and very plastic; no roots; many, very fine and fine, tubular pores; common, very firm, earthy lumps; nearly continuous pressure cutans on ped faces; many, thin, patchy clay films; extremely acid; abrupt, wavy boundary. 9 to 13 inches thick.

B25t—41 to 48 inches, dark reddish-brown (2.5YR 3/4, 3/3 when crushed) heavy silty clay, dark reddish brown (2.5YR 4/4) when dry; many, fine, distinct, dark reddish-brown (2.5YR 3/4) coatings on ped faces; moderate, very fine, subangular blocky structure; hard, firm, sticky and plastic; no roots; many, very fine and fine, tubular pores; many, very firm, earthy lumps; peds have a brittle feel; common iron segregations; few pockets of strongly weathered gravel; continuous pressure cutans on ped faces; many, thin, patchy clay films; extremely acid; clear, wavy boundary. 7 to 9 inches thick.

C1—48 to 62 inches, dark reddish-brown (2.5YR 3/3) clay, dark reddish brown (2.5YR 3/4) when dry; moderate, very fine to medium, subangular blocky structure; very hard, firm, sticky and very plastic; no roots; many, very fine and fine, tubular pores; dark reddish-brown (2.5YR 3/4) coatings on ped faces; continuous pressure cutans on ped faces, some of which appear to be clay films; many, very firm, earthy lumps; few strongly weathered pebbles; extremely acid; gradual, wavy boundary. 14 to 16 inches thick.

C2—62 to 75 inches, dark reddish-brown (5YR 3/4) clay, reddish brown (5YR 4/4) when dry; dark reddish-brown (2.5YR 3/4), stringy, patchy clay films on ped faces; moderate, very fine to medium, subangular blocky structure; hard, firm, sticky and plastic; many, very fine and fine, tubular pores; continuous pressure cutans on ped faces; many weathered pebbles; extremely acid.

The A horizon ranges from 5YR to 2.5YR in hue, from 3 to 4 in value when dry and 2 to 3 when moist, and from 3 to 6 in chroma when dry and 3 to 4 when moist. The B horizon ranges from 2.5YR to 10R in hue, from 2 to 3 in value when moist, and from 4 to 6 in chroma when dry and 3 to 4 when moist. The depth to strongly weathered gravel in the C horizon ranges from 40 inches to more than 60 inches. In many places the A horizon is mixed with the B horizon as a result of deep cultivation.

This soil is used for sugarcane, pineapple, and homesites. (Capability classification IIe, irrigated or nonirrigated; sugarcane group 2; pineapple group 5; pasture group 8; woodland group 7)

Leilehua silty clay, 6 to 12 percent slopes (LeC).—On this soil, runoff is medium and the erosion hazard is moderate. Workability is slightly difficult because of the slope.

This soil is used for sugarcane, pineapple, and pasture. (Capability classification IIIe, irrigated or nonirrigated; sugarcane group 2; pineapple group 6; pasture group 8; woodland group 7)

Lihue Series

This series consists of well-drained soils on uplands on the island of Kauai. These soils developed in material weathered from basic igneous rock. They are gently sloping to steep. Elevations range from nearly sea level to 800 feet. The annual rainfall amounts to 40 to 60 inches. The mean annual soil temperature is 73° F. Lihue soils are geographically associated with Ioleau and Puhi soils.

These soils are used for irrigated sugarcane, pineapple, pasture, truck crops, orchards, wildlife habitat, woodland, and homesites. The natural vegetation consists of lantana, guava, koa haole, joee, kikuyugrass, molassesgrass, guineagrass, bermudagrass, and Java plum.

Lihue silty clay, 0 to 8 percent slopes (LhB).—This soil is on the tops of broad interfluves in the uplands. Included in mapping were small areas of a soil that has a very dark grayish-brown surface layer and a mottled subsoil.

In a representative profile the surface layer is dusky-red silty clay about 12 inches thick. The subsoil, more than 48 inches thick, is dark-red and dark reddish-brown, compact silty clay that has subangular blocky structure. The substratum is soft, weathered rock. The surface layer is strongly acid. The subsoil is slightly acid to neutral.

Permeability is moderately rapid. Runoff is slow, and the erosion hazard is no more than slight. The available water capacity is about 1.5 inches per foot of soil. In places roots penetrate to a depth of 5 feet or more.

Representative profile: Island of Kauai, lat. 21°59′06.7″ N. and long. 159°21′50″ W.

Ap1—0 to 6 inches, dusky-red (2.5YR 3/2) silty clay, yellowish red (5YR 4/8) when dry; cloddy breaking to weak, fine and medium, subangular blocky structure; very hard, firm, sticky and plastic; abundant roots; common very fine and fine pores; many black concretions; strong effervescence with hydrogen peroxide; strongly acid; abrupt, smooth boundary. 4 to 8 inches thick.

Ap2—6 to 12 inches, dusky-red (2.5YR 3/2) silty clay, yellowish red (5YR 4/6) when dry; massive; very hard, friable, sticky and plastic; many roots; many very fine and fine pores; many, very fine, black concretions; strong effervescence with hydrogen peroxide; strongly acid; abrupt, smooth boundary. 4 to 8 inches thick.

B21—12 to 21 inches, dark reddish-brown (2.5YR 3/4) silty clay, red (2.5YR 4/6) when dry; moderate, medium to very fine, subangular blocky structure; hard, friable, sticky and plastic; abundant roots; many very fine and fine pores; many, fine, black concretions; moderate effervescence with hydrogen peroxide; nearly continuous glaze on ped surfaces, glaze looks like clay films; slightly acid; clear, broken boundary. 7 to 10 inches thick.

B22—21 to 27 inches, dark reddish-brown (2.5YR 3/4) silty clay, red (2.5YR 4/6) when dry; strong, very fine, subangular blocky structure; very hard, friable, sticky and plastic; many roots; many very fine and fine pores; nearly continuous glaze on ped faces; common, black concretions; weak effervescence with hydrogen peroxide; few, fine, black, manganese dioxide stains on ped faces; neutral; clear, smooth boundary. 5 to 8 inches thick.

B23—27 to 48 inches, dark reddish-brown (2.5YR 3/4) silty clay, red (2.5YR 4/6) when dry; strong, very fine, subangular and angular blocky structure; hard, firm, sticky and plastic; few roots; many very fine and fine pores; continuous glaze on ped faces, glaze looks like thick clay films; superimposed on the glaze is dark-red (10R 3/6) material that looks like pseudosand under magnification; large, black coatings on primary structural units; neutral; gradual, smooth boundary, 15 to 30 inches thick.

B24—48 to 60 inches, dark-red (2.5YR 3/6) silty clay, red (2.5YR 4/6) when dry; strong, very fine, subangular and angular blocky structure; hard, firm, slightly sticky and plastic; no roots; many very fine and fine pores; thin, patchy coatings that look like clay films; many distinct pressure cutans; ped surfaces have superimposed on them stringy, dark-red (10R 3/6) pseudosand or frostlike coatings; this condition is more prevalent than in the B23 horizon; neutral.

The A horizon ranges from 10R to 5YR in hue, from 2 to 3 in chroma, and from 2 to 3 in value. The B horizon ranges from 10R to 2.5YR in hue and from 4 to 6 in chroma.

This soil is used for sugarcane, pineapple, pasture, truck crops, orchards, wildlife habitat, and homesites. (Capability classification IIe, irrigated or nonirrigated; sugarcane group 1; pineapple group 5; pasture group 5; woodland group 5)

Lihue silty clay, 8 to 15 percent slopes (LhC).—On this soil, runoff is slow and the erosion hazard is slight.

This soil is used for sugarcane, pineapple, pasture, truck crops, orchards, wildlife habitat, and homesites. (Capability classification IIIe, irrigated or nonirrigated; sugarcane group 1; pineapple group 6; pasture group 5; woodland group 5)

Lihue silty clay, 15 to 25 percent slopes (LhD).—On this soil, runoff is medium and the erosion hazard is moderate.

This soil is used for sugarcane, pineapple, pasture, wildlife habitat, and woodland. (Capability classification IVe, irrigated or nonirrigated; sugarcane group 1; pineapple group 6; pasture group 5; woodland group 5)

Lihue silty clay, 25 to 40 percent slopes, eroded (LhE2).—This soil is similar to Lihue silty clay, 0 to 8 percent slopes, except that the surface layer is thin. Runoff is rapid, and the erosion hazard is severe.

This soil is used for pasture, woodland, and wildlife habitat. Small areas are used for pineapple and sugarcane. (Capability classification VIe, nonirrigated; pasture group 5; woodland group 5)

Lihue gravelly silty clay, 0 to 8 percent slopes (LIB).—This soil is similar to Lihue silty clay, 0 to 8 percent slopes, except that it contains ironstone-gibbsite pebbles and has brighter colors in the B horizon. Included in mapping in the Eleele area and north of the town of Hanamaulu were small areas of soils that have a dark yellowish-brown, friable subsoil.

This soil is used for sugarcane, pasture, and homesites. (Capability classification IIe, irrigated or nonirrigated; sugarcane group 1; pineapple group 5; pasture group 5; woodland group 5)

Lihue gravelly silty clay, 8 to 15 percent slopes (LIC).—On this soil, runoff is slow and the erosion hazard is slight. Included in mapping were areas where the slope is as much as 25 percent.

This soil is used for sugarcane, pasture, wildlife habitat, and homesites. (Capability classification IIIe, irrigated or nonirrigated; sugarcane group 1; pineapple group 6; pasture group 5; woodland group 5)

Lolekaa Series

This series consists of well-drained soils on fans and terraces on the windward side of the island of Oahu. These soils developed in old, gravelly colluvium and alluvium. They are gently sloping to very steep. Elevations range from nearly sea level to 500 feet. The annual rainfall amounts to 70 to 90 inches and is well distributed throughout the year. The mean annual soil temperature is 71° F. Lolekaa soils are geographically associated with Alaeloa and Waikane soils.

These soils are used for pasture, homesites, orchards, and truck crops. The natural vegetation consists of guava, Christmas berry, californiagrass, hilograss, and ricegrass.

Lolekaa silty clay, 3 to 8 percent slopes (LoB).—This soil is on terraces and fans. Included in mapping were small areas of Kaneohe soils on uplands and Hanalei soils in narrow drainageways. Also included were small areas of nearly level Lolekaa soils.

In a representative profile the surface layer is dark-brown silty clay about 10 inches thick. The subsoil is 46 to more than 70 inches thick. The upper part is dark-brown silty clay that has subangular blocky structure, and the lower part is dark yellowish-brown loam that has subangular blocky structure. The substratum is strongly weathered gravel. The soil is strongly acid in the surface layer and strongly acid to extremely acid in the subsoil.

Permeability is moderately rapid. Runoff is slow, and the erosion hazard is slight. The available water capacity is about 1.3 inches per foot of soil. Soft, weathered gravel is common in the subsoil but does not affect use and management of the soil for farming. In places roots penetrate to a depth of 5 feet or more.

Representative profile: Island of Oahu, lat. 21°24′57″ N. and long. 157°48′43″ W.

Ap—0 to 10 inches, dark-brown (10YR 3/3) silty clay, dark yellowish brown (10YR 3/4) when dry; strong, very fine and fine, subangular blocky structure; very hard, friable, sticky and plastic; abundant fine and medium roots; many, very fine and fine, interstitial tubular pores; many, very fine, hard, earthy lumps;

strongly acid; abrupt, smooth boundary. 8 to 10 inches thick.

B1—10 to 15 inches, dark-brown (10YR 3/3) silty clay, dark yellowish brown (10YR 3/4) when dry; moderate, very fine and fine, subangular blocky structure; hard, friable, sticky and plastic; plentiful fine roots; many very fine, fine, and medium, tubular pores; continuous, thin coatings on ped faces; evidence of much worm activity; many, hard, earthy lumps; common, soft, strongly weathered pebbles distinctly yellower than matrix, and smeary; very strongly acid; clear, smooth boundary. 4 to 6 inches thick.

B21t—15 to 22 inches, dark-brown (10YR 3/3) silty clay, dark brown (10YR 4/3) when dry; strong, very fine to medium, blocky and subangular blocky structure; hard, friable, sticky and plastic; few fine roots; many very fine, fine, and medium, tubular pores; continuous, thick clay films on ped faces and in pores; dark-brown (7.5YR 4/4 moist), continuous, thick clay films in root channels; many, hard, earthy lumps, compact in place; very strongly acid; clear, smooth boundary. 4 to 10 inches thick.

B22t—22 to 33 inches, dark-brown (10YR 3/3) silty clay, dark brown (10YR 4/3) when dry; strong, medium, subangular blocky structure and strong, very fine and fine, angular blocky; hard, friable, sticky and plastic; few fine roots; common, very fine and fine, tubular pores; continuous, thick clay films on ped faces and dark-brown (7.5YR 4/4 moist), continuous, thick clay films in root channels; many, hard, earthy lumps; very compact in place; few highly weathered rock fragments; extremely acid; clear, wavy boundary. 9 to 18 inches thick.

B23t—33 to 42 inches, dark-brown (10YR 3/3) silty clay, dark brown (10YR 4/3) when dry; strong, very fine and fine, blocky and subangular blocky structure; hard, friable, sticky and plastic; few fine roots; many, fine and very fine, tubular pores; reddish-brown (5YR 4/4 moist), continuous, thin clay films on ped faces and dark-brown (7.5YR 4/4 moist), continuous, thick clay films in root channels; compact in place; approximately 5 percent highly weathered, soft rock fragments that are yellower than the matrix and smeary when rubbed; extremely acid; clear, wavy boundary. 5 to 10 inches thick.

B24t—42 to 55 inches, dark yellowish-brown (10YR 4/4) loam, yellowish brown (10YR 5/4) when dry; moderate, very fine and fine, subangular blocky structure; hard, friable, slightly sticky and slightly plastic; few fine roots; many, very fine and fine, tubular pores; reddish-brown (5YR 4/4 moist), continuous, thin, clay films on ped faces; dark-brown (7.5YR 4/4 moist), continuous, thick clay films in root channels; compact in place; few rock fragments; extremely acid; clear, smooth boundary. 13 to 15 inches thick.

B25t—55 to 62 inches, dark yellowish-brown (10YR 3/4) loam, yellowish brown (10YR 5/4) when moist; moderate to weak, very fine and fine, subangular blocky structure; hard, friable, slightly sticky and slightly plastic; few very fine roots; many, very fine and fine, tubular pores; reddish-brown (5YR 4/4 moist), continuous, thin clay films on ped faces and in pores; 20 to 25 percent weathered rock fragments that are less weathered than those in the B24t horizon; extremely acid.

The depth to strongly weathered gravel and stones ranges from 40 to more than 60 inches. The strongly weathered, soft gravel and stones range from none to many throughout the solum. The A horizon ranges from 2 to 3 in value and chroma when moist. The Bt horizon ranges from 3 to 4 in value when moist and from 3 to 6 in chroma when moist. The texture of the B24t and B25t horizons ranges from loam to silty clay.

This soil is used for pasture, homesites, truck crops, bananas, and papaya. (Capability classification IIe, nonirrigated; pasture group 8; woodland group 7)

Lolekaa silty clay, 8 to 15 percent slopes (LoC).—On this soil, runoff is slow to medium and the erosion hazard is slight to moderate. Workability is slightly difficult because of the slope. Included in mapping were small, eroded spots and small, gravelly areas.

This soil is used for pasture, homesites, papaya, and bananas. (Capability classification IIIe, nonirrigated; pasture group 8; woodland group 7)

Lolekaa silty clay, 15 to 25 percent slopes (LoD).—This soil is on side slopes of terraces and along drainageways. Runoff is medium, and the erosion hazard is moderate. Workability is slightly difficult because of the slope. Included in mapping were small, eroded spots and small, gravelly areas.

This soil is used for pasture. (Capability classification IVe, nonirrigated; pasture group 8; woodland group 7)

Lolekaa silty clay, 25 to 40 percent slopes (LoE).—This soil occurs along drainageways and on fans adjacent to the Koolau Range. Runoff is medium to rapid, and the erosion hazard is moderate to severe. Workability is difficult because of the slope. Included in mapping were small, eroded spots and small, gravelly areas.

This soil is used for pasture. (Capability classification VIe, nonirrigated; pasture group 8; woodland group 7)

Lolekaa silty clay, 40 to 70 percent slopes (LoF).—This soil occurs along drainageways and on fans adjacent to the Koolau Range. Runoff is rapid, and the erosion hazard is severe. It is impractical to cultivate this soil.

This soil is used for pasture. (Capability classification VIIe, nonirrigated; pasture group 8; woodland group 14)

Lualualei Series

This series consists of well-drained soils on the coastal plains, alluvial fans, and on talus slopes on the islands of Kauai, Oahu, Molokai, and Lanai. These soils developed in alluvium and colluvium. They are nearly level and gently sloping. Elevations range from 10 to 125 feet. In most places the annual rainfall amounts to 18 to 30 inches, but it is as low as 10 inches on Lanai and as high as 50 inches on Kauai. Most of the rainfall occurs during storms in the period from November to April. There is a prolonged dry period in summer. The mean annual soil temperature is 75° F. Lualualei soils are geographically associated with Honouliuli, Jaucas, and Kekaha soils.

These soils are used for sugarcane, truck crops, pasture, wildlife habitat, urban development, and military installations. The natural vegetation consists of kiawe, koa haole, bristly foxtail, uhaloa, and fingergrass.

Lualualei clay, 0 to 2 percent slopes (LuA).—This soil is on alluvial fans. Included in mapping were small, stony areas and small areas of Ewa soils.

In a representative profile the surface layer, about 10 inches thick, is very dark grayish-brown, very sticky and very plastic clay that has prismatic structure. The next layer, 37 to more than 42 inches thick, is very dark grayish-brown, very sticky and very plastic clay that has prismatic structure. In addition, it has gypsum crystals. The soil is underlain by coral, gravel, sand, or clay at depths below 40 inches. This soil cracks widely upon drying. It is neutral in the surface layer and medium acid to moderately alkaline in the underlying layers.

Permeability is slow. Runoff is slow, and the erosion hazard is no more than slight. The available water capac-

ity is about 1.4 inches per foot of soil. In places roots penetrate to a depth of 5 feet or more. The shrink-swell potential is high.

Representative profile: Island of Oahu, lat. 21°25'10" N. and long. 158°09'00" W.

A11—0 to 1 inch, very dark grayish-brown (10YR 3/2) clay, very dark gray (10YR 3/1) when moist; strong, fine and very fine, granular structure; very hard, firm, very sticky and very plastic; abundant fine roots; many, fine, interstitial pores; few light-colored sand grains; vertical cracks up to 2½ inches wide; strong effervescence with hydrogen peroxide; neutral; abrupt, smooth boundary. ½ inch to 1½ inches thick.

A12—1 inch to 10 inches, very dark grayish-brown (10YR 3/2) clay, very dark gray (10YR 3/1) when moist; moderate, coarse, prismatic structure breaking to moderate, medium, subangular blocky; very hard, firm, very sticky and very plastic; abundant fine roots; many, fine, tubular pores; some organic litter in the cracks; strong effervescence with hydrogen peroxide; neutral; gradual, smooth boundary. 8 to 12 inches thick.

AC—10 to 22 inches, very dark grayish-brown (10YR 3/2) clay, very dark grayish brown (10YR 3/2) when moist; moderate, coarse, prismatic structure breaking to moderate, medium, subangular blocky; very hard, firm, very sticky and very plastic; abundant fine roots; many, fine, tubular pores; common slickensides; few black specks; few coral sand grains; strong effervescence with hydrogen peroxide; neutral; clear, smooth boundary. 10 to 12 inches thick.

C1—22 to 30 inches, very dark grayish-brown (10YR 3/2), moist and dry, clay; moderate, medium and coarse, subangular blocky structure; hard, firm, very sticky and very plastic; plentiful fine and medium roots, mainly matted between cleavage planes; few, fine and very fine, tubular pores; many weakly grooved slickensides; common black stains in pores and in dendritic pattern on ped faces; few light-colored sand grains; common shiny specks; strong effervescence with hydrogen peroxide; neutral; gradual, smooth boundary. 7 to 10 inches thick.

C2cs—30 to 49 inches, very dark grayish-brown (10YR 3/2), moist and dry, clay; strong, medium and coarse, subangular blocky structure; hard, firm, very sticky and very plastic; few fine roots matted between faces; few, fine, tubular pores; many deeply grooved slickensides; many, fine and medium, gypsum crystals; common black stains in pores and on peds; common shiny specks; few light-colored sand grains; strong effervescence with hydrogen peroxide; medium acid; abrupt, smooth boundary. 17 to 20 inches thick.

C3cs—49 to 60 inches, very dark grayish-brown (10YR 3/2), moist and dry, clay; strong, coarse, subangular blocky structure; extremely hard, very firm, very sticky and very plastic; few fine roots matted between peds; few, fine, tubular pores; many deeply grooved slickensides; common, medium and coarse, gypsum crystals; few shiny specks; strong effervescence with hydrogen peroxide; medium acid.

The A11 horizon is granular when dry but massive when wet. Because of the type of clay, there is considerable swelling and shrinking of the soil as a result of alternate wetting and drying. When the soil dries, it cracks and forms huge blocks 1 foot or more in diameter. When it is wet there is no evidence of the blocks. The A and C horizons range from 7.5YR to 10YR in hue and from 2 to 4 in value. Chroma is either 1 or 2. Gypsum crystals ⅛ inch to 3 inches in diameter are common in the profile, generally below a depth of 30 inches.

This soil is used for sugarcane, truck crops, pasture, wildlife habitat, urban development, and military installations. The very sticky and very plastic nature of the clay makes cultivation difficult and practical only within a narrow range of moisture content. Because of the high shrink-swell potential, considerable care is necessary when using this soil as a site for buildings or highways. (Capability classification IIIs if irrigated, VIs if nonirrigated; sugarcane group 4; pasture group 2; woodland group 4)

Lualualei clay, 2 to 6 percent slopes (LuB).—On this soil, runoff is slow and the erosion hazard is slight. Included in mapping were small, stony areas and small areas where the slope is as much as 12 percent.

This soil is used for sugarcane, truck crops, pasture, urban development, and military installations. (Capability classification IIIe if irrigated, VIs if nonirrigated; sugarcane group 4; pasture group 2; woodland group 4)

Lualualei stony clay, 0 to 2 percent slopes (LvA).—This soil occurs on Oahu on fans adjacent to drainageways. It is similar to Lualualei clay, 0 to 2 percent slopes, except that there are enough stones to hinder machine cultivation.

This soil is used for sugarcane, truck crops, pasture, and military installations. (Capability classification IIIs if irrigated, VIs if nonirrigated; sugarcane group 4; pasture group 2; woodland group 4)

Lualualei stony clay, 2 to 6 percent slopes (LvB).—This soil occurs on Oahu adjacent to drainageways. It is similar to Lualualei clay, 0 to 2 percent slopes, except that there are enough stones to hinder machine cultivation. Runoff is slow, and the erosion hazard is slight. Included in mapping were small areas where the slope is 6 to 12 percent.

This soil is used for urban development, military installations, pasture, truck crops, and sugarcane. (Capability classification IIIe if irrigated, VIs if nonirrigated; sugarcane group 4; pasture group 2; woodland group 4)

Lualualei extremely stony clay, 3 to 35 percent slopes (LPE).—This soil occurs on talus slopes on Oahu and Kauai. The slope range is 3 to 35 percent, but in most places the soil is moderately sloping to steep. This soil is similar to Lualualei clay, 0 to 2 percent slopes, except that there are many stones on the surface and in the profile. It is impractical to cultivate this soil unless the stones are removed. Runoff is medium to rapid, and the erosion hazard is moderate to severe.

This soil is used for pasture. (Capability classification VIIs, nonirrigated; pasture group 2; woodland group 4)

Mahana Series

This series consists of well-drained soils on uplands on the islands of Kauai and Oahu. These soils developed in volcanic ash. They are gently sloping to very steep. Elevations range from 1,000 to 3,000 feet. The annual rainfall amounts to 30 to 45 inches. The mean annual soil temperature is 67° F. Mahana soils are geographically associated with Oli and Puu Opae soils on Kauai and with Kolekole soils on Oahu.

These soils are used for pasture, woodland, wildlife habitat, irrigated sugarcane, and water supply. The natural vegetation consists of puakeawe, aalii, ricegrass, molassesgrass, silver oak, yellow foxtail, lantana, joee, Japanese tea, passion flower, and associated plants.

Mahana silt loam, 6 to 12 percent slopes (MaC).—This soil occurs on ridgetops and moderately sloping uplands.

Included in mapping were some areas where the slope is less than 6 percent.

In a representative profile the surface layer, about 7 inches thick, is dusky-red to dark reddish-brown silt loam that has subangular blocky structure. The subsoil, 41 inches thick, is dark-red to dusky-red silt loam and silty clay loam. The substratum is compact silty clay loam.

Permeability is moderately rapid. Runoff is slow, and the erosion hazard is slight. The available water capacity is about 1.5 inches per foot of soil. In places roots penetrate to a depth of 5 feet or more.

Representative profile: Island of Kauai, lat. 22°01′30″ N. and long. 159°41′11″ W.

A1—0 to 7 inches, dusky-red (10R 3/4) silt loam, dark reddish brown (2.5YR 3/4) when dry; strong, fine and very fine, subangular blocky structure; very hard, friable, sticky and plastic; abundant roots; moderate effervescence with hydrogen peroxide; medium acid; clear, wavy boundary. 6 to 10 inches thick.

B21—7 to 11 inches, dark-red (2.5YR 3/6) silt loam, reddish brown (2.5YR 4/4) when dry; weak, coarse, prismatic structure; slightly hard, very friable, nonsticky and nonplastic; abundant roots; many fine pores; slightly acid; gradual, smooth boundary. 4 to 7 inches thick.

B22—11 to 20 inches, dark-red (2.5YR 3/6) silt loam, reddish brown (2.5YR 4/4) when dry; weak, coarse, prismatic structure; soft, very friable, slightly sticky and slightly plastic, and slightly smeary; abundant roots; many fine pores; medium acid; gradual, smooth boundary. 11 to 16 inches thick.

B23—20 to 35 inches, dark-red (2.5YR 3/6) silt loam, reddish brown (2.5YR 4/4) when dry; weak, coarse, prismatic structure; soft, very friable, slightly sticky and slightly plastic, and smeary; few roots; many fine pores; medium acid; gradual, smooth boundary. 11 to 16 inches thick.

IIB3—35 to 48 inches, dark-red (2.5YR 3/6) silty clay loam, reddish brown (2.5YR 5/4) when dry; weak, fine and medium, subangular blocky structure; slightly hard, friable, sticky and plastic, and slightly smeary; few roots; many fine pores; contains hard, earthy lumps; slightly acid; clear, smooth boundary. 12 to 15 inches thick.

IIC—48 to 61 inches, dark reddish-brown (5YR 3/3) silty clay loam; some coatings of dark red (10R 3/8), reddish brown (2.5YR 4/4) when dry; moderate, fine and medium, angular and subangular blocky structure; compact in place; hard, firm, sticky and plastic; few roots; many fine and very fine pores; continuous stress cutans; dark-red coatings that look like clay films; weak, patchy slickensides; medium acid.

The A horizon ranges from 10R to 2.5YR in hue, from 3 to 4 in chroma, and from 2 to 3 in value. The B horizon ranges from 7.5R to 2.5YR in hue and from 4 to 8 in chroma. The texture of the B horizon ranges from very fine sandy loam to silty clay loam.

This soil is used for pasture, woodland, wildlife habitat, pineapple, and sugarcane. (Capability classification IIIe if irrigated, IVe if nonirrigated; sugarcane group 1; pineapple group 6; pasture group 6; woodland group 5)

Mahana silt loam, 12 to 20 percent slopes (MaD).—On this soil, runoff is medium and the erosion hazard is moderate.

This soil is used for pasture, woodland, wildlife habitat, and sugarcane. (Capability classification IVe, irrigated or nonirrigated; sugarcane group 1; pineapple group 6; pasture group 6; woodland group 5)

Mahana silt loam, 12 to 20 percent slopes, severely eroded (MaD3).—This soil has a profile like that of Mahana silt loam, 6 to 12 percent slopes, except that most of the surface layer has been removed by erosion. Runoff is rapid, and the erosion hazard is severe. Included in mapping were some areas where all of the surface layer and part of the subsoil have been removed by erosion. Also included were small areas where the slope is less than 12 percent.

This soil is used for pasture, wildlife habitat, and woodland. (Capability classification IVe if irrigated, VIe if nonirrigated; sugarcane group 1; pineapple group 6; pasture group 6; woodland group 5)

Mahana silt loam, 20 to 35 percent slopes (MaE).—On this soil, runoff is rapid and the erosion hazard is severe.

This soil is used for pasture, woodland, wildlife habitat, and water supply. (Capability classification VIe, nonirrigated; pasture group 6; woodland group 5)

Mahana silt loam, 20 to 35 percent slopes, severely eroded (MaE3).—This soil has a profile like that of Mahana silt loam, 6 to 12 percent slopes, except that the surface layer and part of the subsoil have been removed by erosion. There are a few gullies. Runoff is very rapid, and the erosion hazard is very severe.

This soil is used for pasture and woodland. (Capability classification VIe, nonirrigated; pasture group 6; woodland group 5)

Mahana silty clay loam, 6 to 12 percent slopes, eroded (McC2).—Erosion has removed most of the surface layer of this soil, and the surface texture is now silty clay loam. Otherwise, the profile is like that of Mahana silt loam, 6 to 12 percent slopes. Included in mapping were small areas where the slope is less than 6 percent.

This soil is used for sugarcane, pineapple, and pasture. (Capability classification IIIe if irrigated, IVe if nonirrigated; sugarcane group 1; pineapple group 6; pasture group 6; woodland group 5)

Mahana silty clay loam, 12 to 20 percent slopes, eroded (McD2).—This soil has a profile like that of Mahana silt loam, 6 to 12 percent slopes, except for the texture of the surface layer. Most of the surface layer has been removed by erosion. Runoff is rapid, and the erosion hazard is severe.

This soil is used for sugarcane, pineapple, and pasture. (Capability classification IVe, irrigated or nonirrigated; sugarcane group 1; pineapple group 6; pasture group 6; woodland group 5)

Mahana silty clay loam, 20 to 35 percent slopes, eroded (McE2).—This soil has a profile like that of Mahana silt loam, 6 to 12 percent slopes, except for the texture of the surface layer. Most of the surface layer has been removed by erosion. Runoff is very rapid, and the erosion hazard is very severe.

Included in mapping were areas where all of the surface layer and part of the subsoil have been removed by erosion. Also included were small, stony areas and reddish-colored upland soils that are underlain by a panlike layer at a depth of 15 to 50 inches.

This soil is used for pasture, pineapple, and irrigated sugarcane. (Capability classification VIe, nonirrigated; pasture group 6; woodland group 5)

Mahana-Badland complex (MBL).—This complex consists of Mahana soils and Badland. Mahana soils make

up 40 to 70 percent of the acreage, and Badland 30 to 60 percent. The Mahana soils are similar to Mahana silt loam, 6 to 12 percent slopes, except that the texture is silty clay loam and the soils are moderately steep to very steep. Runoff is medium to very rapid, and the erosion hazard is moderate to very severe.

This complex is used for pasture. (Mahana part is in capability classification IVe, nonirrigated; pasture group 6; woodland group 5. Badland part is in capability classification VIIIe, nonirrigated)

Makaalae Series

This series consists of well-drained soils on uplands on the island of Maui. These soils developed in volcanic ash. They are moderately sloping to steep. Elevations range from nearly sea level to 1,500 feet. The annual rainfall amounts to 60 to 90 inches. It is well distributed throughout the year. The mean annual soil temperature is 73° F. Makaalae soils are geographically associated with Hana, Honomanu, and Kaupo soils.

These soils are used for pasture, wildlife habitat, and water supply. The natural vegetation consists of guava, kaimiclover, kikuyugrass, rattailgrass, and yellow foxtail.

Makaalae silty clay, 7 to 25 percent slopes (MID).—This soil is on rough, low mountain slopes. Included in mapping were small areas of Hana and Honomanu soils. In a few places scattered stones are on the surface. Also included were a few cinder cones.

In a representative profile the surface layer is very dark brown silty clay about 10 inches thick. Below this is very dark grayish-brown silty clay, about 30 inches thick, that has subangular blocky structure. The substratum is fragmental Aa lava. The soil is strongly acid in the surface layer and medium to slightly acid in the subsoil.

Permeability is moderate. Runoff is slow to medium, and the erosion hazard is slight to moderate. In places the roots penetrate to a depth of 4 feet.

Representative profile: Island of Maui, lat. 20°41′18″ N. and long. 156°03′06″ W.

Ap—0 to 10 inches, very dark brown (10YR 2/2) silty clay, very dark grayish brown (10YR 3/2) when dry; strong, very fine and fine, subangular blocky structure; very hard, firm, sticky and plastic; abundant fine and very fine roots; common fine pores; common worm casts; 5 to 15 percent stones; few weathered pebbles; strongly acid; clear, wavy boundary. 8 to 12 inches thick.

C1—10 to 24 inches, very dark grayish-brown (10YR 3/2) silty clay, dark brown (10YR 3/3) when dry; moderate, very fine and fine, subangular blocky structure; hard, firm, very sticky and very plastic, and weakly smeary; plentiful fine roots; many fine pores; few worm casts; 30 to 50 percent stones; 5 to 10 percent gravel; few, red, weathered cinders; few pale-yellow mineral grains; medium acid; gradual, smooth boundary. 10 to 14 inches thick.

C2—24 to 40 inches, very dark grayish-brown (10YR 3/2) silty clay, dark brown (10YR 3/3) when dry; moderate, very fine and fine, subangular blocky structure; hard, friable, very sticky and plastic, and weakly smeary; plentiful fine and medium roots; many fine pores; many, red, weathered cinders; 50 to 70 percent hard gravel, cobblestones, and stones; slightly acid.

IIC3—40 inches, fragmental Aa lava.

The depth to Aa lava ranges from 24 to 48 inches. The C horizon ranges from 7.5YR to 10YR in hue and from 2 to 4 in chroma when moist. The content of gravel, cobblestones, and stones in the C2 horizon ranges from 50 to 70 percent. Smeariness in the C horizon increases with elevation.

This soil is used for pasture, wildlife habitat, and water supply. (Capability classification IVe, nonirrigated; pasture group 8; woodland group 7)

Makaalae extremely stony silty clay, 7 to 25 percent slopes (MJD).—This soil is similar to Makaalae silty clay, 7 to 25 percent slopes, except that stones cover 3 to 15 percent of the surface. Included in mapping were small areas that are less stony. In places outcrops of Aa lava along drainageways are common. Also included were a few cinder cones.

This soil is used for pasture, wildlife habitat, and water supply. (Capability classification VIIs, nonirrigated; pasture group 8; woodland group 7)

Makaalae clay, 7 to 40 percent slopes (MWE).—The slope range of this soil is 7 to 40 percent, but in most places the slope is 20 to 30 percent. The surface layer of this soil developed in a mixture of volcanic ash, and the subsoil in material derived from basic igneous rock. The surface layer is very sticky and very plastic. Included in mapping were small, stony areas.

This soil is used for pasture and wildlife habitat. (Capability classification VIe, nonirrigated; pasture group 8; woodland group 7)

Makalapa Series

This series consists of well-drained soils on uplands on the island of Oahu, near Salt Lake Crater, Diamond Head, and the Mokapu Peninsula. These soils formed in volcanic tuff. They are gently sloping to moderately steep. Elevations range from 20 to 200 feet. The annual rainfall amounts to 20 to 35 inches. A long dry period occurs in summer. The mean annual soil temperature is 74° F. Makalapa soils are geographically associated with Kokokahi and Mamala soils.

These soils are used for urban development and pasture. The natural vegetation consists of kiawe, koa haole, lantana, bermudagrass, and fingergrass.

Makalapa clay, 2 to 6 percent slopes (MdB).—This soil is gently sloping. Included in mapping were small areas of Mamala soils and small areas of saline soils within Salt Lake Crater and Diamond Head.

In a representative profile the surface layer is very dark grayish-brown clay about 8 inches thick. The next layer, 18 to 36 inches thick, is very dark grayish-brown clay to silty clay loam that has subangular blocky structure. It is underlain by light-gray to dark grayish-brown, weathered volcanic tuff. The clays are very sticky and very plastic, and they crack widely upon drying. The soil is mildly alkaline in the surface layer and mildly alkaline to moderately alkaline in the next layer.

Permeability is slow. Runoff is slow, and the erosion hazard is slight. The available water capacity is about 1.4 inches per foot of soil. Roots penetrate to the volcanic tuff. Workability is difficult because the clay is very sticky and very plastic. The shrink-swell potential is high.

Representative profile: Island of Oahu, lat. 21°21′52″ N. and long. 157°55′01″ W.

Ap1—0 to 2 inches, very dark grayish-brown (10YR 3/2) clay, very dark gray (10YR 3/1) when dry; strong, very fine and fine, granular structure; very hard, firm, very sticky and very plastic; abundant fine and very fine roots; few fine fragments of coral; strong effervescence with hydrogen peroxide; slight effervescence with hydrochloric acid; mildly alkaline; abrupt, smooth boundary. 1 to 3 inches thick.

Ap2—2 to 8 inches, very dark grayish-brown (10YR 3/2), moist and dry, clay; moderate, fine and very fine, granular structure and moderate, coarse, subangular blocky; hard, firm, very sticky and very plastic; abundant fine roots; common, fine and very fine, interstitial and tubular pores; few fine fragments of coral; strong effervescence with hydrogen peroxide; slight effervescence with hydrochloric acid; mildly alkaline; abrupt, smooth boundary. 6 to 10 inches thick.

AC—8 to 20 inches, very dark grayish-brown (10YR 3/2), moist and dry, clay; lozengelike peds (4 by 18 inches) that break to weak, medium, subangular blocky structure; very hard, firm, very sticky and very plastic; abundant fine and medium roots; few to common, fine and very fine, tubular and interstitial pores; common to many slickensides; common fine sand grains; few angular rock fragments; slight effervescence with hydrogen peroxide; slight effervescence with hydrochloric acid; mildly alkaline; gradual, smooth boundary. 8 to 12 inches thick.

C1—20 to 30 inches, very dark grayish-brown (10YR 3/2), moist and dry, clay; lozengelike peds (1 to 2 inches thick and 2 to 8 inches long); very hard, very firm, very sticky and very plastic; plentiful fine roots mainly matted on ped faces, few within peds; few, very fine, tubular pores; many distinct slickensides; few tuff fragments; slight effervescence with hydrogen peroxide; strong effervescence with hydrochloric acid; moderately alkaline; clear, wavy boundary. 8 to 12 inches thick.

C2—30 to 38 inches, very dark grayish-brown (10YR 3/2), moist and dry, silty clay loam; moderate, fine and medium, blocky and subangular blocky structure; slightly hard, firm, very sticky and very plastic; few fine roots; few, fine, tubular pores; many, very pale brown (10YR 7/3 dry), pebble-size tuff fragments; common distinct slickensides; slight effervescence with hydrogen peroxide; strong effervescence with hydrochloric acid; moderately alkaline; clear, smooth boundary. 4 to 12 inches thick.

C3—38 inches, highly decomposed, light-gray (10YR 7/2) to dark grayish-brown (10YR 4/2) volcanic tuff; strong effervescence with hydrochloric acid.

The thickness of the soil over volcanic tuff ranges from 27 to 49 inches. The amount of pebble-size fragments of tuff on the surface and in the profile ranges from 5 to 20 percent. When the soil is dry, there are cracks 2 inches or more wide and 20 to 30 inches deep. The profile ranges from 10YR to 7.5YR in hue and from 2 to 4 in chroma when moist. The texture of the upper part of the C horizon ranges from clay to silty clay loam.

This soil is used for urban development and pasture. (Capability classification IIIs, nonirrigated; sugarcane group 4; pasture group 3)

Makalapa clay, 6 to 12 percent slopes (MdC).—This soil is similar to Makalapa clay, 2 to 6 percent slopes, except that it occurs on fans. Runoff is slow to medium, and the erosion hazard is slight to moderate.

This soil is used for urban development and pasture. (Capability classification IVe, nonirrigated; sugarcane group 4; pasture group 3)

Makalapa clay, 12 to 20 percent slopes (MdD).—On this soil, runoff is medium and the erosion hazard is moderate.

This soil is used for urban development and pasture. (Capability classification IVe, nonirrigated; sugarcane group 4; pasture group 3)

Makapili Series

This series consists of well-drained soils on uplands on the island of Kauai. These soils developed in material weathered from basic igneous rock. They are nearly level to steep. Elevations range from 100 to 350 feet. The annual rainfall amounts to 70 to 80 inches. The mean annual soil temperature is 72° F. Makapili soils are geographically associated with Pooku soils.

These soils are used for pasture, irrigated sugarcane, and woodland. The natural vegetation consists of pangolagrass, kikuyugrass, kaimiclover, sensitiveplant, guava, and Java plum.

Makapili silty clay, 0 to 8 percent slopes (MeB).—This soil is on broad upland ridges.

In a representative profile the surface layer is brown silty clay about 12 inches thick. The subsoil, about 48 inches thick, is reddish-brown, dark reddish-brown, and yellowish-red clay loam and silty clay that has subangular blocky structure. The substratum is silty clay. The surface layer is strongly acid. The subsoil is very strongly acid.

Permeability is moderately rapid. Runoff is slow, and the erosion hazard is slight. The available water capacity is about 1.4 inches per foot of soil. In places roots penetrate to a depth of 5 feet or more.

Representative profile: Island of Kauai, lat. 22°13′14″ N. and long. 159°28′46.9″ W.

Ap—0 to 12 inches, brown (10YR 4/3) silty clay, brown (10YR 4/3) when rubbed, brown (10YR 5/3) when dry; strong, fine, subangular blocky structure; very hard, friable, sticky and plastic; abundant micro, very fine, fine, and medium roots; many micro and very fine, tubular pores; many, very fine, interstitial pores; few pebbles (hard, weathered rock); strongly acid; abrupt, smooth boundary. 11 to 13 inches thick.

B1—12 to 14 inches, reddish-brown (5YR 4/3) clay loam, reddish brown (5YR 4/4) when rubbed, dark reddish brown (5YR 3/4) when dry; weak, medium, subangular blocky structure; very hard, friable, slightly sticky and slightly plastic; abundant micro, very fine, fine, and medium roots; many, micro, very fine, tubular pores; common, fine and medium, tubular pores; thin, patchy pressure cutans; many higher chroma, sugarlike granules in pores; many worm channels and worm casts; strongly acid; clear, smooth boundary. 0 to 3 inches thick.

B21—14 to 22 inches, dark reddish-brown (5YR 3/3) clay loam, reddish brown (5YR 4/4) when rubbed, dark brown (7.5YR 4/4) when dry; moderate, fine and very fine, subangular blocky structure; very hard, firm, slightly sticky and slightly plastic; plentiful micro, very fine, and fine roots and few medium roots; many micro and very fine, tubular pores; many, very fine, interstitial pores; nearly continuous pressure cutans on peds; many higher chroma, sugarlike granules in pores; very strongly acid; clear, wavy boundary. 7 to 9 inches thick.

B22—22 to 28 inches, reddish-brown (5YR 4/4) clay loam, reddish brown (5YR 4/4) when rubbed; dark reddish brown (5YR 3/3) with sugary coatings of reddish brown (5YR 5/4) when dry; weak, fine and very fine, subangular blocky structure; very hard, firm, slightly sticky and slightly plastic; plentiful micro and very fine roots and few fine and medium roots; many micro and very fine tubular pores and common, fine, tubular pores; many, very fine, interstitial

pores; continuous pressure cutans on peds; many higher chroma, sugarlike granules in pores; many, fine, black specks; very strongly acid; clear, wavy boundary. 4 to 8 inches thick.

B23—28 to 44 inches, dark reddish-brown (5YR 3/4) clay loam, yellowish red (5YR 4/6) when rubbed; dark reddish brown (5YR 3/4) with sugary coatings of reddish brown (5YR 5/4) when dry; moderate, fine and very fine, subangular blocky structure; very hard, firm, slightly sticky and slightly plastic; few micro and very fine roots; many micro and very fine, tubular pores and few, fine, tubular pores; many, very fine, interstitial pores; continuous pressure cutans on peds; many higher chroma, sugarlike granules in pores; about 40 percent of volume is weathered rock impregnated with white and yellowish-white secondary minerals; about 2 percent of the weathered rock is more than 1 inch in diameter; very strongly acid; gradual, wavy boundary. 14 to 18 inches thick.

B24—44 to 60 inches, dark reddish-brown (2.5YR 3/4) silty clay, reddish brown (5YR 4/4) when rubbed, reddish brown (5YR 4/4) when dry; strong, fine and very fine, subangular blocky structure; very hard, firm, sticky and plastic; few micro and very fine roots; many micro and very fine, tubular pores and common, fine, tubular pores; many, very fine, interstitial pores; continuous pressure cutans on peds; many higher chroma, sugarlike granules in pores; few, fine, black specks; weathered rock is impregnated with white and yellowish-white secondary minerals and makes up more than 50 percent of the volume; about 5 percent of the weathered rock is more than 1 inch in diameter; very strongly acid.

The A horizon ranges from 2.5Y to 10YR in hue, from 3 to 4 in value, and from 2 to 3 in chroma. The upper part of the B horizon ranges from 5YR to 7.5YR in hue and from 3 to 4 in value and chroma. It ranges from weak subangular blocky structure to massive. The B22 horizon ranges from clay loam to silty clay loam in texture.

This soil is used for pasture and sugarcane. (Capability classification IIe, irrigated or nonirrigated; pasture group 10; woodland group 9)

Makapili silty clay, 8 to 15 percent slopes (MeC).—On this soil, runoff is slow to medium and the erosion hazard is slight to moderate.

This soil is used for pasture and sugarcane. (Capability classification IIIe, irrigated or nonirrigated; pasture group 10; woodland group 9)

Makapili silty clay, 15 to 25 percent slopes (MeD).—On this soil, runoff is medium and the erosion hazard is moderate to severe.

This soil is used for pasture. (Capability classification IVe, irrigated or nonirrigated; pasture group 10; woodland group 9)

Makapili silty clay, 25 to 40 percent slopes (MeE).—This soil has a profile like that of Makapili silty clay, 0 to 8 percent slopes, except that the surface layer is thinner. Runoff is rapid, and the erosion hazard is severe.

This soil is used for pasture and woodland. (Capability classification VIe, nonirrigated; pasture group 10; woodland group 9)

Makawao Series

This series consists of well-drained soils on uplands on the island of Maui. These soils developed in volcanic ash and in material weathered from basic igneous rock. They are gently sloping to moderately sloping. Elevations range from 1,200 to 2,500 feet. The annual rainfall amounts to 60 to 90 inches. The mean annual soil temperature is 69° F. Makawao soils are geographically associated with Haiku, Kailua, and Olinda soils.

These soils are used for pasture. Small acreages are used for pineapple, truck crops, and homesites. The natural vegetation consists of bermudagrass, eucalyptus, guava, hilograss, kaimiclover, and kikuyugrass.

Makawao silty clay, 3 to 7 percent slopes (MfB).—This soil is on smooth side slopes and intermediate slopes in the uplands. Included in mapping were small areas of Haiku and Kailua soils.

In a representative profile the surface layer is dark reddish-brown silty clay about 9 inches thick. The subsoil, about 30 inches thick, is dark reddish-brown silty clay that has subangular blocky structure. The substratum is soft, weathered basic igneous rock. The soil is strongly acid to medium acid in the surface layer and slightly acid in the subsoil.

Permeability is moderately rapid. Runoff is slow, and the erosion hazard is slight. In places roots penetrate to a depth of 5 feet or more.

Representative profile: Island of Maui, lat. 20°51′02″ N. and long. 156°18′36″ W.

Ap1—0 to 4 inches, dark reddish-brown (5YR 3/3) silty clay, reddish brown (5YR 4/4) when dry; strong, very fine, subangular blocky structure; hard, firm, sticky and plastic; abundant roots; many very fine pores; slight effervescence with hydrogen peroxide; strongly acid; clear, wavy boundary. 3 to 6 inches thick.

Ap2—4 to 9 inches, dark reddish-brown (5YR 3/3) silty clay, yellowish red (5YR 4/6) when dry; strong, very fine, subangular blocky structure; hard, firm, sticky and plastic, and weakly smeary; abundant roots; common fine pores; slight effervescence with hydrogen peroxide; medium acid; abrupt, wavy boundary. 3 to 7 inches thick.

B21t—9 to 12 inches, dark reddish-brown (2.5YR 3/4) silty clay, reddish brown (2.5YR 4/4) when dry; moderate, fine and medium, subangular blocky structure; hard, friable, sticky and plastic, and weakly smeary; few roots; many fine and very fine pores; thin, patchy clay films on peds; few weathered pebbles; slightly acid; clear, wavy boundary. 2 to 4 inches thick.

B22t—12 to 19 inches, dark reddish-brown (2.5YR 3/4) silty clay, reddish brown (2.5YR 4/4) when dry; moderate, fine and very fine, subangular blocky structure; slightly hard, friable, sticky and plastic, and weakly smeary; few roots; many fine and very fine pores; thin, continuous clay films on peds; 10 to 15 percent weathered gravel; slightly acid; gradual, wavy boundary. 5 to 9 inches thick.

B3—19 to 37 inches, dark reddish-brown (5YR 3/4) silty clay, reddish brown (5YR 5/4) when dry; moderate, fine and very fine, subangular blocky structure; slightly hard, friable, sticky and plastic, and moderately smeary; few roots; many fine and medium pores; continuous, gelatinlike coatings on peds; 10 to 15 percent weathered gravel; slightly acid; gradual, wavy boundary. 15 to 20 inches thick.

C—37 to 60 inches, gray, highly weathered rock with 15 to 20 percent dark-brown (10YR 3/3) silty clay, brown (10YR 5/3) when dry; weak, fine and medium, subangular blocky structure; hard, firm, sticky and plastic, and moderately smeary; very few roots; common fine and medium pores; slightly acid.

Smeariness ranges from weak at the lower elevations to moderate at the higher elevations. The A horizon ranges from 4 to 5 in value when dry and, in chroma, from 2 to 3 when moist and 4 to 6 when dry. The Bt horizon ranges from 5YR to 2.5YR in hue, from 3 to 4 in value when moist and 4 to 5

when dry, and from 3 to 4 in chroma when moist and 3 to 5 when dry. The texture is silty clay or clay.

This soil is used for pasture. Small acreages are used for pineapple, truck crops, and homesites. (Capability classification IIe, nonirrigated; pineapple group 5; pasture group 8; woodland group 7)

Makawao silty clay, 7 to 15 percent slopes (MfC).—This soil is similar to Makawao silty clay, 3 to 7 percent slopes, except that it is moderately sloping to strongly sloping. Runoff is slow to medium, and the erosion hazard is slight to moderate. Included in mapping were small, moderately steep areas and a few very steep cinder cones. In places there are small, eroded spots where soft, weathered rock fragments are in the surface layer.

This soil is used for pasture. Small acreages are used for homesites. (Capability classification IIIe, nonirrigated; pineapple group 6; pasture group 8; woodland group 7)

Makaweli Series

This series consists of well-drained soils on uplands on the island of Kauai. These soils developed in material weathered from basic igneous rock. They are gently sloping to steep. Elevations range from nearly sea level to 500 feet. The annual rainfall amounts to 20 to 35 inches. Three-fourths of it occurs from October through March. The mean annual soil temperature is 74° F. Makaweli soils are geographically associated with Niu soils.

These soils are used for irrigated sugarcane, pasture, and homesites. The natural vegetation consists of kiawe, lantana, fingergrass, klu, koa haole, and piligrass.

Makaweli silty clay loam, 0 to 6 percent slopes (MgB).—This soil is on the tops of broad interfluves in the uplands. Included in mapping were small areas that have a subsoil of silty clay and some areas that have strong structure in the subsoil.

In a representative profile the surface layer is dusky-red silty clay loam about 12 inches thick. The subsoil, 48 inches thick, is dusky-red, friable silt loam and silty clay loam that has prismatic and subangular blocky structure. The substratum is soft, weathered basic igneous rock. The soil is slightly acid in the surface layer and slightly acid to neutral in the subsoil.

Permeability is moderate. Runoff is slow, and the erosion hazard is slight. The available water capacity is about 1.6 inches per foot of soil. In places roots penetrate to a depth of 5 feet or more.

Representative profile: Island of Kauai, lat. 21°53′45″ N. and long. 159°33′55″ W.

Ap1—0 to 7 inches, dusky-red (10R 3/2) silty clay loam, dark red (10R 3/6) when dry; cloddy breaking to weak, very fine to medium, granular structure; hard, friable, sticky and plastic; abundant very fine and fine roots; many very fine and fine pores; many very fine, black concretions; moderately magnetic; numerous fragments of charcoal from burning cane; violent effervescence with hydrogen peroxide; slightly acid; clear, smooth boundary. 6 to 8 inches thick.

Ap2—7 to 12 inches, dusky-red (10R 3/3) silty clay loam, dusky-red (10R 3/2) material mixed by tillage, dusky red (10R 3/4) when dry; weak, medium and coarse, subangular blocky structure; hard, friable, slightly sticky and slightly plastic; abundant roots; common, very fine and fine, tubular pores; many black concretions; moderately magnetic; strong effervescence with hydrogen peroxide; slightly acid; clear, smooth boundary. 4 to 6 inches thick.

B21—12 to 25 inches, dusky-red (10R 3/4) silt loam, red (10R 4/6) when dry; weak, coarse, prismatic structure; slightly hard, very friable, slightly sticky and plastic; plentiful roots; many, very fine and fine, medium pores; common black concretions; moderately magnetic; black manganese dioxide staining along root channels; strong effervescence with hydrogen peroxide; neutral; clear, smooth boundary. 11 to 15 inches thick.

B22—25 to 36 inches, dusky-red (10R 3/4) silty clay loam, dark red (10R 3/6) when dry; weak, coarse, prismatic structure breaking to weak, fine to coarse, subangular blocky; pockets of moderate, very fine, subangular blocky structure; slightly hard, friable, slightly sticky and plastic; plentiful roots; many very fine and fine pores and common medium pores; few black concretions; patchy, glazed surfaces on peds that look like pressure surfaces; root channels are lined with black manganese dioxide staining; moderately magnetic; slight effervescence with hydrogen peroxide; neutral; gradual, wavy boundary. 9 to 13 inches thick.

B23—36 to 60 inches, dusky-red (10R 3/3) silty clay loam, dark red (10R 3/6) when dry; weak, medium and fine, subangular blocky structure; pockets of moderate, medium, subangular blocky structure; slightly hard, friable, slightly sticky and plastic; few fine and medium roots that tend to be confined between ped faces; many very fine and fine pores; few black manganese dioxide concretions; common, very fine, weathered mineral particles that tend to impart a gritty feel; few glazed coatings on ped surfaces that look like pressure faces; several large stones; slight effervescence with hydrogen peroxide; neutral.

In most places the A horizon is 10R in hue, but in some places it is 2.5YR. It ranges from 2 to 3 in chroma and from 2 to 3 in value. The B horizon ranges from 3 to 6 in chroma. The grade of structure of the B horizon ranges from weak to moderate.

This soil is used for irrigated sugarcane and pasture. (Capability classification IIe if irrigated, IVc if nonirrigated; sugarcane group 1; pasture group 2)

Makaweli silty clay loam, 6 to 12 percent slopes (MgC).—On this soil, runoff is medium and the erosion hazard is moderate. Included in mapping were small, severely eroded areas.

This soil is used for sugarcane, pasture, and homesites. (Capability classification IIIe if irrigated, IVe if nonirrigated; sugarcane group 1; pasture group 2)

Makaweli silty clay loam, 12 to 20 percent slopes (MgD).—On this soil, runoff is rapid and the erosion hazard is severe. Included in mapping were small, severely eroded areas.

This soil is used for sugarcane and pasture. (Capability classification IVe, irrigated or nonirrigated; sugarcane group 1; pasture group 2)

Makaweli silty clay loam, 20 to 35 percent slopes, eroded (MgE2).—This soil has a profile like that of Makaweli silty clay loam, 0 to 6 percent slopes, except that the surface layer is thinner. Runoff is rapid, and the erosion hazard is severe. Included in mapping were areas of less sloping soils and areas in the vicinity of Nomilo fishpond where the soils are underlain by cinders.

This soil is used for pasture. (Capability classification VIe, nonirrigated; pasture group 2)

Makaweli stony silty clay loam, 0 to 6 percent slopes (MhB).—This soil is similar to Makaweli silty clay loam, 0 to 6 percent slopes, except that it is stony. Some of

the stones are more than 27 inches in diameter. The stones hinder cultivation.

This soil is used for sugarcane and pasture. (Capability classification IIe if irrigated, IVs if nonirrigated; sugarcane group 1; pasture group 2)

Makaweli stony silty clay loam, 6 to 12 percent slopes (MhC).—This soil is similar to Makaweli silty clay loam, 0 to 6 percent slopes, except that it is moderately sloping and is stony. The stones hinder cultivation. Runoff is medium, and the erosion hazard is moderate.

This soil is used for sugarcane and pasture. (Capability classification IIIe if irrigated, IVe if nonirrigated; sugarcane group 1; pasture group 2)

Makaweli stony silty clay loam, 12 to 20 percent slopes (MhD).—This soil is similar to Makaweli silty clay loam, 0 to 6 percent slopes, except that it is moderately steep and stony. The stones hinder cultivation. Runoff is rapid, and the erosion hazard is severe.

This soil is used for sugarcane and pasture. (Capability classification IVe, irrigated or nonirrigated; sugarcane group 1; pasture group 2)

Makaweli stony silty clay loam, 20 to 35 percent slopes (MhE).—This soil is similar to Makaweli silty clay loam, 0 to 6 percent slopes, except that it is steep and stony and the surface layer is thinner. Runoff is rapid, and the erosion hazard is severe.

This soil is used for pasture. (Capability classification VIe, nonirrigated; pasture group 2)

Makena Series

This series consists of well-drained soils on uplands on the island of Maui. These soils developed in volcanic ash. They are gently to moderately sloping. Elevations range from nearly sea level to 500 feet. The annual rainfall amounts to 10 to 20 inches. Most of it occurs in winter. The mean annual soil temperature is 75° F. Makena soils are geographically associated with Keawakapu and Oanapuka soils.

These soils are used for pasture and wildlife habitat. The natural vegetation consists of bristly foxtail, feather fingergrass, ilima, and kiawe.

Makena loam, stony complex, 3 to 15 percent slopes (MXC).—This complex is on the lower leeward slopes of Haleakala, between Makena and Kamaole. It consists of Makena loam and Stony land. Stony land occurs on low ridges and makes up 30 to 60 percent of the complex. Makena loam occurs as gently sloping areas between the low ridges of Stony land.

Included in mapping were small areas of Keawakapu and Oanapuka soils. Also included were areas where outcrops of Aa lava cover as much as 15 percent of the surface.

In a representative profile the surface layer, about 4 inches thick, is very dark brown loam that has platy structure. The subsoil, about 19 inches thick, is very dark grayish-brown and dark yellowish-brown silt loam that has prismatic structure. The substratum is dark yellowish-brown cobbly silt loam. The soil is mildly alkaline in the surface layer and subsoil.

On the Makena part of the complex, permeability is moderately rapid, runoff is slow to medium, and the erosion hazard is slight to moderate. The available water capacity is about 1.8 inches per foot of soil. On the Stony land part, permeability is very rapid and there is no erosion hazard.

Representative profile of Makena loam: Island of Maui, lat. 20°30′32″ N. and long. 156°26′14″ W.

A1—0 to 4 inches, very dark brown (10YR 2/2) loam, brown (10YR 4/3) when dry; weak, thin, platy structure; soft, very friable, nonsticky and nonplastic; few fine roots; few fine and very fine pores; mildly alkaline; abrupt, smooth boundary. 2 to 6 inches thick.

B21—4 to 12 inches, very dark grayish-brown (10YR 3/2) silt loam, brown (10YR 4/3) when dry; weak, coarse, prismatic structure; soft, very friable, nonsticky and nonplastic; plentiful fine roots; few fine pores; mildly alkaline; gradual, wavy boundary. 6 to 11 inches thick.

B22—12 to 23 inches, dark yellowish-brown (10YR 3/4) silt loam, yellowish brown (10YR 5/4) when dry; weak, coarse, prismatic structure; slightly hard, very friable, slightly sticky and slightly plastic; plentiful fine roots; common fine pores; mildly alkaline; gradual, wavy boundary. 8 to 13 inches thick.

C1—23 to 34 inches, dark yellowish-brown (10YR 3/4) silt loam, yellowish brown (10YR 5/4) when dry; massive; soft, very friable, nonsticky and nonplastic; plentiful fine and medium roots; many fine pores; few Aa lava cobblestones; mildly alkaline; gradual, wavy boundary. 8 to 13 inches thick.

C2ca—34 to 44 inches, dark yellowish-brown (10YR 3/4) silt loam, yellowish brown (10YR 5/4) when dry; massive; soft, very friable, nonsticky and nonplastic; plentiful fine and medium roots; few fine pores; has gritty feel because of small cinders; 10 to 20 percent cobblestone-size Aa lava; strong effervescence with hydrochloric acid; moderately alkaline; clear, wavy boundary. 9 to 12 inches thick.

IIC3—44 inches, fragmental Aa lava that contains a little soil material in cracks; the Aa lava has carbonate encrustations on the surface.

The depth to Aa lava is more than 40 inches. Surface stoniness varies from nonstony to extremely stony near lava flows and drainageways. The B horizon ranges from 3 to 4 in value when moist and 4 to 5 when dry and from 2 to 4 in chroma when moist and 3 to 4 when dry. The texture is loam or silt loam.

This complex is used for pasture and wildlife habitat. (Makena part is in capability classification VIs, nonirrigated; pasture group 1. Stony land part is in capability classification VIIs, nonirrigated)

Makiki Series

This series consists of well-drained soils on alluvial fans and terraces in the city of Honolulu on the island of Oahu. These soils formed in alluvium mixed with volcanic ash and cinders. They are nearly level. Elevations range from 20 to 200 feet. The annual rainfall amounts to 30 to 60 inches. Most of it falls between November and April. The mean annual soil temperature is 73° F. Makiki soils are geographically associated with Kaena and Tantalus soils.

These soils are used almost entirely for urban purposes.

Makiki clay loam, 0 to 2 percent slopes (MkA).—This soil is on smooth fans and terraces. Included in mapping were small, stony areas and small areas of Kaena soils.

In a representative profile the surface layer is dark-brown clay loam about 20 inches thick. The subsoil, about 10 inches thick, is dark-brown clay loam that has subangular blocky structure. It contains cinders and rock fragments. The subsoil is underlain by similar material,

about 24 inches thick, that is massive. Below this are volcanic cinders. The soil is strongly acid to medium acid.

Permeability is moderately rapid. Runoff is slow, and the erosion hazard is no more than slight. The available water capacity is about 1.7 inches per foot of soil. In places roots penetrate to a depth of 5 feet or more.

Representative profile: Island of Oahu, lat. 21°18′28″ N. and long. 157°50′20″ W.

Ap1—0 to 10 inches, dark-brown (7.5YR 3/2) clay loam, dark brown (7.5YR 4/2) when dry; moderate, very fine and fine, granular structure; very hard, firm, very sticky and very plastic; abundant fine and medium roots; common, very fine and fine, interstitial pores; common, fine, highly weathered basalt fragments; slight effervescence with hydrogen peroxide; strongly acid; gradual, smooth boundary. 8 to 12 inches thick.

Ap2—10 to 20 inches, dark-brown (7.5YR 3/2) clay loam, dark brown (7.5YR 4/4) when dry; moderate, coarse, subangular blocky structure; hard, firm, very sticky and very plastic; abundant fine and medium roots; common, very fine and fine, tubular pores and few, coarse, tubular pores; common, fine, highly weathered basalt and cinder fragments; slight effervescence with hydrogen peroxide; strongly acid; clear, smooth boundary. 8 to 12 inches thick.

B2—20 to 30 inches, dark-brown (7.5YR 3/2) clay loam, dark brown (7.5YR 4/3) when dry; moderate, fine and very fine, subangular blocky structure; hard, friable, very sticky and very plastic; plentiful fine roots; common, very fine and fine, tubular pores and few, coarse, tubular pores; few, fine, distinct, reddish-brown stains that appear to be decomposed cinders; common, fine, gritty fragments of highly weathered basalt and cinders; medium acid; abrupt, smooth boundary. 8 to 15 inches thick.

IIC—30 to 54 inches, dark-brown (7.5YR 3/2) clay loam, dark brown (7.5YR 4/3) when dry; massive and stratified; slightly hard, friable, slightly sticky and slightly plastic; few fine roots; common fine, medium, and coarse tubular pores; horizon consists of bands of unweathered, fine, pebble-size black cinders mixed with highly weathered, rounded pebbles and soil material similar in color, consistence, and texture to the B2 horizon. At a depth of about 60 inches, the soil material is underlain by gravelly, fine-textured alluvium mixed with cinders; medium acid.

The depth to unweathered cinders or stony or gravelly alluvium is variable within short distances and ranges from 30 to more than 60 inches. Layers of sandy loam or silt loam are common in the profile. The solum ranges from 10YR to 5YR in hue. When moist, the A horizon ranges from 2 to 3 in value and from 1 to 3 in chroma.

This soil is almost entirely in urban use. The headquarters of the Hawaii Sugar Planters Association Experiment Station is located on this soil. (Capability classification IIIc, nonirrigated)

Makiki stony clay loam, 0 to 3 percent slopes (MlA).—This soil is similar to Makiki clay loam, 0 to 2 percent slopes, except that there are enough stones to hinder cultivation. The stones are angular and make up about 15 percent of the soil by volume. The depth to basalt or cinders varies from 20 to 60 inches. Basalt outcrops are common. The soil is neutral to slightly acid.

This soil is almost entirely in urban use. The University of Hawaii uses a small area for truck crop experiments. (Capability classification IIIs, nonirrigated)

Mala Series

This series consists of well-drained soils on bottoms of drainageways and on alluvial fans on the coastal plains. These soils occur on the islands of Molokai and Lanai. They formed in recent alluvium. Elevations range from nearly sea level to 100 feet. The annual rainfall amounts to 10 to 25 inches. Most of it occurs between November and April. The summers are hot and dry; there is very little rain. The mean annual soil temperature is 75° F. Mala soils are geographically associated with Jaucas, Kealia, and Pulehu soils.

These soils are used for pasture, alfalfa, truck crops, orchards, and wildlife habitat. The natural vegetation consists of kiawe, bristly foxtail, feather fingergrass, ilima, and Australian saltbush.

Mala silty clay, 0 to 3 percent slopes (MmA).—This soil is on fans along the coastal plains.

In a representative profile the surface layer, about 7 inches thick, is dark reddish-brown silty clay that has platy structure. It is underlain by stratified layers of dark reddish-brown and very dark gray alluvium that is mostly silty clay. These layers are 47 to more than 59 inches thick. The soil is slightly acid to neutral in the surface layer and in the upper part of the subsoil and moderately alkaline in the lower part of the subsoil.

Permeability is moderate. Runoff is slow, and the erosion hazard is no more than slight. The available water capacity is about 1.4 inches per foot of soil. In places roots penetrate to a depth of 5 feet or more.

In low areas this soil is subject to flooding for short periods during heavy rains. Many shallow wells have been dug in this soil. The water is brackish, and care is required if it is used for irrigation purposes. The soil is easily compacted, and subsoiling may be necessary.

Representative profile: Island of Molokai, lat. 21°05′44″ N. and long. 157°10′50″ W.

A1—0 to 7 inches, dark reddish-brown (5YR 3/3), moist and dry, silty clay; moderate, thin, platy structure breaking to weak, very fine, granular; lower 2 inches is massive; hard, friable, sticky and plastic; many roots; strong effervescence with hydrogen peroxide; slightly acid; abrupt, smooth boundary. 4 to 8 inches thick.

C1—7 to 13 inches, dark reddish-brown (2.5YR 2/4) silty clay, dark reddish gray (5YR 4/2) when dry; cloddy breaking to very weak, fine, granular structure; hard, friable, sticky and plastic; common roots; few very fine pores; many coral sand grains; few pebbles; strong effervescence with hydrogen peroxide; slightly acid; abrupt, smooth boundary. 5 to 7 inches thick.

C2—13 to 35 inches, dark reddish-brown (2.5YR 2/4 and 3/3), moist and dry, highly stratified layers of silty clay that has platy and granular structure; slightly hard, friable, sticky and plastic; common roots; few very fine pores; many coral sand grains; moderate effervescence with hydrogen peroxide; neutral; abrupt, smooth boundary. 18 to 24 inches thick.

C3—35 to 40 inches, very dark gray (5YR 3/1) silty clay, dark gray (10YR 4/1) when dry; massive; hard, very friable, very sticky and very plastic; many roots; few very fine pores; few coral sand grains; slight effervescence with hydrogen peroxide; mildly alkaline; abrupt, smooth boundary. 4 to 8 inches thick.

IIC4—40 to 60 inches, coral sand; the upper 4 inches is dark gray (10YR 4/1 moist), and the lower part light gray (10YR 7/1 moist); mildly alkaline.

The soil is underlain by coral sand or weathered rock at a depth of more than 40 inches. The profile is highly stratified. The thickness, texture, and consistence of the layers in the C horizon vary considerably. The stratified layers are silty clay, silty clay loam, and silt loam. There are few to common pebbles and stones in the profile. A few areas have surface cracking, but this is not common. The C1, C2, and C3 horizons range from 5YR to 2.5YR in hue. These soils are slightly saline where they grade to the Kealia soils.

This soil is used for pasture, alfalfa, truck crops, orchards, and wildlife habitat. (Capability classification I if irrigated, VIc if nonirrigated; pasture group 1)

Mala silty clay, 3 to 7 percent slopes (MmB).—On this soil, runoff is slow and the erosion hazard is slight to moderate. In many places the soil is slightly to moderately eroded. There are a few gullies formed by intermittent streams. In some places there are a few stones on the surface.

This soil is used for pasture. (Capability classification IIe if irrigated, VIc if nonirrigated; pasture group 1)

Malama Series

This series consists of excessively drained, extremely stony, very shallow, organic soils on uplands on the island of Maui. These soils developed in organic material. They are gently sloping to moderately steep. Elevations range from nearly sea level to 1,000 feet. The annual rainfall amounts to 60 to 90 inches. It is well distributed throughout the year. The mean annual soil temperature is 72° F. Malama soils are geographically associated with Hana and Opihikao soils.

These soils are used mostly for water supply. Small acreages are used for orchard crops and pasture. The natural vegetation consists of californiagrass, guava, hala, kukui, ohia, and treefern.

Malama extremely stony muck, 3 to 25 percent slopes (MYD).—This soil is on rough Aa lava flows. Included in mapping were small areas of outcrops of Aa lava near the edge and on the sides of small gulches.

In a representative profile the surface layer is black muck about 8 inches thick. The substratum is fragmental Aa lava. It contains a small amount of organic material in voids in the upper 24 inches. The amount of organic material decreases with depth.

Permeability is very rapid. Runoff is very slow, and the erosion hazard is no more than slight. In places roots penetrate to a depth of 2 feet.

Representative profile: Island of Maui, lat. 20°48′12″ N. and long. 156°02′44″ W.

1—0 to 8 inches, black (10YR 2/1) extremely stony muck, very dark gray (10YR 3/1) when dry; weak, very fine, granular structure when moist; strong, fine and very fine, subangular blocky structure when dry; very hard, friable, nonsticky and nonplastic, and moderately smeary; abundant roots; many pores; tendency to dehydrate irreversibly; low bulk density; 50 to 70 percent gravel, cobblestones, and stone-size fragments of Aa lava; medium acid; clear, irregular boundary. 3 to 8 inches thick.

IIC1—8 to 28 inches, aa lava; 5 to 15 percent of the material in voids is from the overlying horizon; abundant roots in the upper part.

IIC2—28 to 48 inches, fragmental Aa lava.

The muck layer ranges from 3 to 8 inches in thickness.

This soil is used mostly for water supply. Small acreages are used for orchard crops and pasture. (Capability classification VIs, nonirrigated; pasture group 9; woodland group 8)

Mamala Series

This series consists of shallow, well-drained soils along the coastal plains on the islands of Oahu and Kauai. These soils formed in alluvium deposited over coral limestone and consolidated calcareous sand. They are nearly level to moderately sloping. Elevations range from nearly sea level to 100 feet on Oahu but extend to 850 feet on Kauai. The annual rainfall amounts to 18 to 25 inches, most of which occurs between November and April. The mean annual soil temperature is 74° F. Mamala soils are geographically associated with Ewa, Honouliuli, and Lualualei soils on Oahu, and with Koloa and Nohili soils on Kauai.

These soils are used for sugarcane, truck crops, orchards, and pasture. The natural vegetation consists of kiawe, koa haole, bristly foxtail, and swollen fingergrass.

Mamala stony silty clay loam, 0 to 12 percent slopes (MnC).—The slope range of this soil is 0 to 12 percent, but in most places the slope does not exceed 6 percent. Stones, mostly coral rock fragments, are common in the surface layer and in the profile. Included in mapping were areas of Ewa soils. Also included were nonstony areas and areas where the slope is as much as 20 percent.

In a representative profile the surface layer is dark reddish-brown stony silty clay loam about 8 inches thick. The subsoil is dark reddish-brown silty clay loam about 11 inches thick. The soil is underlain by coral limestone and consolidated calcareous sand at depths of 8 to 20 inches. This soil is neutral to mildly alkaline.

Permeability is moderate. Runoff is very slow to medium, and the erosion hazard is slight to moderate. The available water capacity is about 2.2 inches per foot in the surface layer and 1.9 inches per foot in the subsoil. Roots are affected by the coral limestone and consolidated sand. The stones hinder, but do not prevent, cultivation.

Representative profile: Island of Oahu, lat. 21°20′20″ N. and long. 158°03′08″ W.

Ap—0 to 8 inches, dark reddish-brown (5YR 3/3) stony silty clay loam, dark reddish brown (5YR 3/4) when dry; moderate, fine and medium, subangular blocky structure; hard, firm, sticky and plastic; few fine, medium, and coarse roots; few, fine, tubular pores; compacted by recent cultivation; affected by mill waste from hydro-separator; about 20 percent coral rock fragments 1/16 inch to 4 inches in size; some mixing of lower horizon by cultivation; moderate effervescence with hydrogen peroxide; strong effervescence with hydrochloric acid; neutral; abrupt, smooth boundary. 6 to 8 inches thick.

B2—8 to 19 inches, dark reddish-brown (2.5YR 3/4) stony silty clay loam, dark red (2.5YR 3/6) when dry; weak, coarse and medium, subangular blocky structure; slightly hard, friable, slightly sticky and plastic; common fine and medium roots; common very fine, fine, and medium, tubular pores; common worm casts and wormholes 1/16 to 1/4 inch in size, coated with organic stains; about 40 percent coral fragments and sand grains; strong effervescence with hydrochloric acid; mildly alkaline; abrupt, broken boundary. 4 to 11 inches thick.

IIR—19 inches, coral limestone.

The depth to coral limestone ranges from 8 to 20 inches but may extend to 40 inches in places on Kauai. The A horizon ranges from 5YR to 7.5YR in hue; in value, from

2 to 4 when moist and 3 to 4 when dry; and, in chroma, from 3 to 4 when moist and 4 to 6 when dry. The B horizon ranges from 5YR to 2.5YR in hue; in value, from 2 to 4 when moist and 3 to 4 when dry; and, in chroma, from 3 to 4 when moist and 4 to 6 when dry. On Kauai, this soil is generally redder; it has hues of 2.5YR to 5YR in the A horizon and 10R to 5YR in the B horizon.

This soil is used for sugarcane, truck crops, and pasture. (Capability classification IIIs if irrigated, VIs if nonirrigated; sugarcane group 1; pasture group 2)

Manana Series

This series consists of well-drained soils on uplands on the island of Oahu. These soils developed in material weathered from basic igneous rock. They are gently sloping to steep. Elevations range from 500 to 1,200 feet. The annual rainfall amounts to 40 to 60 inches. It is well distributed throughout the year. The mean annual soil temperature is 70° F. Manana soils are geographically associated with Leilehua, Paaloa, and Wahiawa soils.

These soils are used for sugarcane, pineapple, and pasture. The natural vegetation consists of bermudagrass, Christmas berry, false staghornfern, glenwoodgrass, guava, koa, ohia, and sedges.

Manana silty clay loam, 6 to 12 percent slopes (MoC).—This soil is on smooth slopes in the uplands. Included in mapping were small areas of Leilehua, Paaloa, and Wahiawa soils.

In a representative profile the surface layer is dark reddish-brown silty clay loam about 8 inches thick. The subsoil, about 42 inches thick, is dusky-red, dark reddish-gray, and dark reddish-brown silty clay that has subangular blocky structure. A nonporous, panlike sheet, 1/8 inch to 1/4 inch thick, occurs in the subsoil at depths ranging from 15 to 50 inches. The substratum is soft, weathered basic igneous rock. The soil is very strongly acid in the surface layer and very strongly acid to extremely acid in the subsoil.

The depth to the panlike sheet is 15 to 30 inches. Permeability is moderately rapid above the pan and moderate below. Runoff is medium, and the erosion hazard is moderate. The available water capacity is about 1.2 inches per foot in the surface layer and 1.3 inches per foot in the subsoil. Roots penetrate to a depth of 15 to 30 inches, except that where there are cracks in the panlike sheet, they may extend to a depth of 4 feet.

Representative profile: Island of Oahu, lat. 21°27′50″ N. and long. 157°58′10″ W.

Ap—0 to 8 inches, dark reddish-brown (2.5YR 3/4), moist and dry, silty clay loam; moderate, very fine and fine, subangular blocky structure; hard, friable, slightly sticky and slightly plastic; abundant very fine roots; many, very fine and fine, interstitial pores; common glistening specks; many firm aggregates when moist; high bulk density; some dusky-red (10R 3/4) material from B horizon mixed by tillage; moderately magnetic; very strongly acid; abrupt, smooth boundary. 6 to 9 inches thick.

B21—8 to 15 inches, dusky-red (10R 3/4) light silty clay, dark red (10R 3/6) when dry; moderate, very fine and fine, subangular blocky structure; hard, friable, sticky and plastic; abundant very fine roots; many, very fine and fine, tubular pores; few weak pressure cutans on ped faces; few worm casts; matted roots at lower boundary; moderately magnetic; very strongly acid; abrupt, smooth boundary. 6 to 8 inches thick.

B22t—15 to 27 inches, dark reddish-gray (5YR 4/2) gritty silty clay, reddish brown (5YR 4/3) when dry; strong, very fine, subangular blocky structure; very hard, firm, slightly sticky and plastic; few roots in vertical cracks; many, very fine and fine, tubular pores; many, patchy, dark-red (2.5YR 3/6) coatings with frostlike material on ped faces; many, moderately thick, discontinuous clay films on ped faces; nonporous, panlike sheet, 1/8- to 1/4-inch thick, caps this horizon; common highly weathered pebbles cemented by illuvial material; moderately magnetic; extremely acid; gradual, wavy boundary. 10 to 14 inches thick.

B23t—27 to 42 inches, dark reddish-brown (5YR 3/3) silty clay, dark reddish brown (5YR 3/4) when dry; strong, very fine, subangular blocky structure; hard, firm, slightly sticky and plastic; few roots in vertical cracks; common, very fine, tubular pores; dark-red (2.5YR 3/6), continuous, moderately thick clay films on ped faces; compact in place; few fragments of highly weathered gravel; moderately magnetic; extremely acid; gradual, wavy boundary. 15 to 18 inches thick.

B24t—42 to 50 inches, dark reddish-brown (5YR 3/4) silty clay, reddish brown (5YR 4/4) when dry; moderate, very fine, subangular blocky structure; hard, friable, slightly sticky and plastic; few roots in vertical cracks; many, very fine and fine, tubular pores; dark-red (2.5YR 3/6), continuous, moderately thick clay films on ped faces; common highly weathered pebbles; moderately magnetic; extremely acid.

The size and number of highly weathered rock fragments vary considerably within short distances. The depth to the panlike sheet ranges from 15 to 50 inches, except that in small, eroded areas the pan may be less than 15 inches below the surface. The A horizon ranges from 2.5YR to 5YR in hue, from 2 to 3 in value when moist, and from 2 to 4 in chroma when moist or dry. The texture is silty clay or silty clay loam. Effervescence with hydrogen peroxide is none to slight, and reaction ranges from extremely acid to very strongly acid. The B horizon below the thin, panlike sheet ranges from 5YR to 10R in hue; the red hues are normally in the upper part. The texture is silty clay or clay.

This soil is used for sugarcane, pineapple, and pasture. (Capability classification IIIe if irrigated, IVe if nonirrigated; sugarcane group 1; pineapple group 6; pasture group 6; woodland group 6)

Manana silty clay loam, 2 to 6 percent slopes (MoB).—On this soil, runoff is slow and the erosion hazard is slight.

This soil is used for sugarcane, pineapple, and pasture. (Capability classification IIe if irrigated, IIIe if nonirrigated; sugarcane group 1; pineapple group 5; pasture group 6; woodland group 6)

Manana silty clay loam, 12 to 25 percent slopes, eroded (MoD2).—This soil is similar to Manana silty clay loam, 6 to 12 percent slopes, except that it is moderately steep. The surface layer is 4 to 6 inches thick as a result of past erosion. Included in mapping were small spots where the subsoil is exposed. The depth to the panlike sheet is less than 15 inches. Runoff is rapid, and the erosion hazard is severe.

This soil is used for sugarcane, pineapple, and pasture. (Capability classification VIe, irrigated or nonirrigated; sugarcane group 1; pasture group 6; woodland group 6)

Manana silty clay, 3 to 8 percent slopes (MpB).—On this soil, runoff is slow and the erosion hazard is slight. The depth to the panlike sheet is 30 to 50 inches.

This soil is used for sugarcane and pineapple. (Capability classification IIe, irrigated or nonirrigated; sugarcane group 1; pineapple group 5; pasture group 6; woodland group 6)

Manana silty clay, 8 to 15 percent slopes (MpC).—On this soil, the depth to the panlike sheet is 30 to 50 inches.

This soil is used for sugarcane, pineapple, and pasture. (Capability classification IIIe, irrigated or nonirrigated; sugarcane group 1; pineapple group 6; pasture group 6; woodland group 6)

Manana silty clay, 15 to 25 percent slopes (MpD).—On this soil the depth to the panlike sheet is 30 to 50 inches. Runoff is medium, and the erosion hazard is moderate.

This soil is used for sugarcane, pineapple, and pasture. (Capability classification IVe, irrigated or nonirrigated; sugarcane group 1; pineapple group 6; pasture group 6; woodland group 6)

Manana silty clay, 12 to 25 percent slopes, eroded (MpD2).—This soil is similar to Manana silty clay loam, 6 to 12 percent slopes, except that it is moderately steep, is eroded, and has a silty clay texture. In most areas nearly all of the original surface layer has been removed by erosion. Included in mapping were spots where the subsoil is exposed. Runoff is rapid, and the erosion hazard is severe.

This soil is used for sugarcane, pasture, and homesites. (Capability classification VIe, irrigated or nonirrigated, sugarcane group 1; pasture group 6; woodland group 6)

Manana silty clay, 25 to 40 percent slopes (MpE).—On this soil, runoff is medium to rapid and the erosion hazard is moderate to severe. The depth to the panlike sheet is 30 to 50 inches.

This soil is used for homesites and pasture. (Capability classification VIe, nonirrigated; pasture group 6; woodland group 6)

Marsh

Marsh (MZ) consists of wet, periodically flooded areas covered dominantly with grasses and bulrushes or other herbaceous plants. It occurs as small, low-lying areas along the coastal plains. Water stands on the surface, but marsh vegetation thrives. The water is fresh or brackish, depending on proximity to the ocean. Included in mapping were small areas of mangrove swamp and small areas of open water. (Capability classification VIIIw, nonirrigated)

Mokuleia Series

This series consists of well-drained soils along the coastal plains on the islands of Oahu and Kauai. These soils formed in recent alluvium deposited over coral sand. They are shallow and nearly level. Elevations range from nearly sea level to 100 feet. The annual rainfall amounts to 15 to 40 inches on Oahu and 50 to 100 inches on Kauai. The mean annual soil temperature is 74° F. Mokuleia soils are geographically associated with Hanalei, Jaucas, and Keaau soils.

In this survey area a poorly drained variant of the Mokuleia series was mapped. This soil, Mokuleia clay loam, poorly drained variant, is described in alphabetical order, along with other mapping units of this series.

These soils are used for sugarcane, truck crops, and pasture. The natural vegetation consists of kiawe, klu, koa haole, and bermudagrass in the drier areas and napiergrass, guava, and joee in the wetter areas.

Mokuleia clay loam (Mt).—This soil occurs as small areas on the coastal plains. It is nearly level. Included in mapping were small areas of Jaucas soils; small areas of very deep, well-drained soils in drainageways; and small areas of poorly drained clay soils underlain by reef limestone.

In a representative profile the surface layer is very dark grayish-brown clay loam about 16 inches thick. The next layer, 34 to more than 48 inches thick, is dark-brown and light-gray, single-grain sand and loamy sand. The surface layer is neutral in reaction, and the underlying material is moderately alkaline.

Permeability is moderate in the surface layer and rapid in the subsoil. Runoff is very slow, and the erosion hazard is no more than slight. The available water capacity is about 1.8 inches per foot in the surface layer and about 1.0 inch per foot in the subsoil. In places roots penetrate to a depth of 5 feet or more.

Representative profile: Island of Oahu, lat. 21°34′49″ N. and long. 158°10′09″ W.

Ap—0 to 16 inches, very dark grayish-brown (10YR 3/2) clay loam, dark grayish brown (10YR 4/2) when dry; moderate, very fine and fine, granular and subangular blocky structure; hard, firm, sticky and plastic; plentiful fine roots; many, very fine and fine, interstitial pores; few, fine and very fine, tubular pores; common wormholes and worm casts; horizon consists of about 25 percent coral sand; slight effervescence with hydrogen peroxide; violent effervescence with hydrochloric acid; neutral; abrupt, wavy boundary. 10 to 16 inches thick.

IIC1—16 to 22 inches, dark-brown (10YR 4/3) loamy sand, brown (10YR 5/3) when dry; massive; soft, slightly hard, nonsticky and nonplastic; plentiful fine roots; porous; few pieces of reef limestone; horizon consists of about 80 percent coral sand; violent effervescence with hydrochloric acid; moderately alkaline; abrupt, smooth boundary. 6 to 20 inches thick.

IIC2—22 to 50 inches, light-gray (10YR 7/2), moist and dry, coral sand; single grain; loose when moist or dry, nonsticky and nonplastic; few fine roots; porous; few pieces of coral; violent effervescence with hydrochloric acid; moderately alkaline.

The depth to coral sand ranges from 12 to 30 inches. The A horizon ranges from 10YR to 5YR in hue and from 1 to 3 in value when moist and 3 to 5 when dry. It ranges from 1 to 3 in chroma when moist and 1 to 3 when dry. The IIC1 horizon ranges from 10YR to 7.5YR in hue, from 3 to 6 in value when moist and 4 to 7 when dry, and from 1 to 3 in chroma.

This soil is used for sugarcane, truck crops, and pasture. (Capability classification IIs if irrigated, VIs if nonirrigated; sugarcane group 1; pasture group 3)

Mokuleia clay (Mtb).—This soil has a profile like that of Mokuleia clay loam, except for the texture of the surface layer. It is nearly level. Permeability is slow in the surface layer. Workability is difficult because of the sticky, plastic clay.

This soil is used for sugarcane and pasture. (Capability classification IIIs if irrigated, VIs if nonirrigated; sugarcane group 1; pasture group 3)

Mokuleia fine sandy loam (Mr).—This soil occurs on the eastern and northern coastal plains of Kauai. It is nearly level. This soil has a profile like that of Mokuleia clay loam, except for the texture of the surface layer.

Permeability is moderately rapid in the surface layer and rapid in the subsoil. Runoff is very slow, and the erosion hazard is slight. The available water capacity is about 1 inch per foot in the surface layer and 0.7 inch per foot in the subsoil. Included in mapping were small areas where the slope is as much as 8 percent.

This soil is used for pasture. (Capability classification IIIs if irrigated, IVs if nonirrigated; sugarcane group 1; pasture group 3)

Mokuleia loam (Ms).—This soil has a profile like that of Mokuleia clay loam, except that the surface layer is loam and in most places is about 8 inches thick. It is nearly level.

This soil is used for sugarcane, truck crops, and pasture. (Capability classification IIs if irrigated, VIs if nonirrigated; sugarcane group 1; pasture group 3)

Mokuleia clay loam, poorly drained variant (Mta).—This soil occurs on Kauai. It is nearly level. The soil is poorly drained, and in this way, it differs from other soils of the Mokuleia series. The surface layer is dark brown to black and is mottled.

This soil is used for sugarcane, taro, and pasture. (Capability classification IIIw, irrigated or nonirrigated; sugarcane group 3; pasture group 3)

Molokai Series

This series consists of well-drained soils on uplands on the islands of Maui, Lanai, Molokai, and Oahu. These soils formed in material weathered from basic igneous rock. They are nearly level to moderately steep. Elevations range mainly from nearly sea level to 1,000 feet but are as much as 1,500 feet on Lanai. The annual rainfall amounts to 20 to 25 inches, most of which occurs between November and April. The summers are hot and dry. The mean annual soil temperature is 73° F. Molokai soils are geographically associated with Holomua, Keahua, Lahaina, and Uwala soils.

In this survey area a shallow variant of the Molokai series was mapped. This soil, Molokai silty clay loam, shallow variant, 15 to 25 percent slopes, severely eroded, is described in alphabetical order, along with other mapping units of this series.

These soils are used for sugarcane, pineapple, pasture, wildlife habitat, and homesites. The natural vegetation consists of kiawe, ilima, uhaloa, feather fingergrass, and buffelgrass.

Molokai silty clay loam, 0 to 3 percent slopes (MuA).—This soil is on smooth slopes.

In a representative profile the surface layer is dark reddish-brown silty clay loam about 15 inches thick. The subsoil, about 57 inches thick, is dark reddish-brown silty clay loam that has prismatic structure. The material at depths between 35 and 64 inches is moderately compact in place. The substratum is soft, weathered rock. The soil is slightly acid to neutral, except that areas used for pineapple are commonly very strongly acid or extremely acid in the surface layer.

Permeability is moderate. Runoff is slow, and the erosion hazard is slight. The available water capacity is about 1.3 inches per foot of soil. In places roots penetrate to a depth of 5 feet or more.

Representative profile: Island of Molokai, lat. 21°08′36″ N. and long. 157°03′05″ W.

Ap1—0 to 7 inches, dark reddish-brown (2.5YR 3/4) silty clay loam, dark red (2.5YR 3/6) when dry; weak, very fine to medium, granular structure; slightly hard, friable, slightly sticky and plastic; many roots; many interstitial pores; many, very fine, black concretions that effervesce with hydrogen peroxide; strong effervescence with hydrogen peroxide; extremely acid; clear, wavy boundary. 6 to 7 inches thick.

Ap2—7 to 15 inches, dark reddish-brown (2.5YR 3/4) silty clay loam, dark red (2.5YR 3/6) when dry; weak, medium and coarse, subangular blocky structure breaking to moderate, fine and very fine, granular; slightly hard, friable, sticky and plastic; common roots; common, very fine, tubular and interstitial pores; common, fine, black concretions; violent effervescence with hydrogen peroxide; very strongly acid; clear, smooth boundary. 8 to 9 inches thick.

B21—15 to 35 inches, dark reddish-brown (2.5YR 3/4) silty clay loam, red (2.5YR 4/6) when dry; weak, coarse, prismatic structure breaking to weak, coarse, subangular blocky; slightly hard, friable, sticky and plastic; no roots; many, very fine and fine, tubular pores; few, shiny, patchy pressure cutans on prisms; common, fine, black concretions; strong effervescence with hydrogen peroxide; slightly acid; gradual, wavy boundary. 14 to 22 inches thick.

B22—35 to 64 inches, dark reddish-brown (2.5YR 3/4) silty clay loam, red (2.5YR 4/6) when dry; weak, coarse, prismatic structure breaking to strong, very fine and fine, subangular blocky; slightly hard, firm in place, sticky and plastic; no roots; many, very fine and fine, tubular pores and common, medium, tubular pores; common, patchy pressure cutans on peds; common, patchy illuviation cutans on ped surfaces; few, very fine, black concretions; moderately compact in place; moderate effervescence with hydrogen peroxide; neutral; gradual, wavy boundary. 27 to 30 inches thick.

B3—64 to 72 inches, dark reddish-brown (5YR 3/3) clay loam, dark reddish brown (5YR 3/4) when dry; moderate, fine and very fine, subangular and angular blocky structure; slightly hard, friable, slightly sticky and plastic; no roots; common, very fine and fine, tubular pores; thin, patchy illuviation cutans on peds; the walls of the larger pores are lined with red illuviation cutans; common, hard, earthy lumps; few, very fine, black concretions; slight effervescence with hydrogen peroxide; neutral.

The number and size of black concretions that effervesce with hydrogen peroxide decrease with depth. In places rock cores occur in the profile, but they are generally at a depth below 40 inches. The A horizon is 5YR, 2.5YR, or 10R in hue and ranges from 2 to 3 in value when moist, from 4 to 6 in chroma when dry, and from 4 to 5 when moist. The B2 horizon is 2.5YR or 10R in hue and ranges from 2 to 3 in value when moist and, in chroma, from 3 to 4 when moist and 4 to 6 when dry.

This soil is used entirely for sugarcane on Maui and Oahu. It is used for pineapple, pasture, and wildlife habitat on Molokai and Lanai. (Capability classification I if irrigated, IVc if nonirrigated; sugarcane group 1; pineapple group 1; pasture group 2)

Molokai silty clay loam, 3 to 7 percent slopes (MuB).—On this soil, runoff is slow to medium and the erosion hazard is slight to moderate. Included in mapping were a few small areas that are eroded to soft, weathered rock. Also included in mapping on Oahu were small areas of dark reddish-brown silty clay loams that overlie fine-textured, gravelly alluvium and small areas of dark reddish-brown silty clay soils that have a mottled subsoil.

This soil is used for sugarcane, pineapple, pasture, wildlife habitat, and homesites. (Capability classification

IIe if irrigated, IVc if nonirrigated; sugarcane group 1; pineapple group 2; pasture group 2)

Molokai silty clay loam, 3 to 7 percent slopes, severely eroded (MuB3).—This soil occurs on Molokai. It has a profile like that of Molokai silty clay loam, 0 to 3 percent slopes, except that most of the surface layer and, in places, part of the subsoil have been removed by wind and water erosion. Runoff is medium, and the hazard of wind and water erosion is severe.

This soil is used entirely for pasture and wildlife habitat. Most of the vegetation is dormant in summer. (Capability classification IIIe if irrigated, IVe if nonirrigated; sugarcane group 1; pineapple group 2; pasture group 2)

Molokai silty clay loam, 7 to 15 percent slopes (MuC).—This soil occurs on knolls and sharp slope breaks. Runoff is medium, and the erosion hazard is moderate.

This soil is used for sugarcane, pineapple, pasture, wildlife habitat, and homesites. (Capability classification IIIe if irrigated, IVe if nonirrigated; sugarcane group 1; pineapple group 3; pasture group 2)

Molokai silty clay loam, 7 to 15 percent slopes, severely eroded (MuC3).—This soil occurs on Molokai. It has a profile like that of Molokai silty clay loam, 0 to 3 percent slopes, except that most of the surface layer and part of the subsoil have been removed by wind and water erosion. Runoff is medium to rapid, and the hazard of wind and water erosion is severe. There are a few small gullies in areas not under cultivation. Pebble-size, weathered rock fragments are common in the plow layer in cultivated areas.

Most of this soil is used for pasture and wildlife habitat. Small areas are used for pineapple. (Capability classification IVe if irrigated, VIe if nonirrigated; pineapple group 3; pasture group 2)

Molokai silty clay loam, 15 to 25 percent slopes (MuD).—This soil occurs on Oahu. In most places the slope does not exceed 20 percent. Runoff is medium, and the erosion hazard is severe. Workability is slightly difficult because of the slope. Included in mapping were small areas where boulder cores are exposed.

This soil is used for sugarcane and pineapple. (Capability classification IVe, irrigated or nonirrigated; sugarcane group 1; pineapple group 3; pasture group 2)

Molokai silty clay loam, shallow variant, 15 to 25 percent slopes, severely eroded (MvD3).—This soil occurs on the sides of drainageways. In most places all of the surface layer and part of the subsoil have been removed, and about 12 to 20 inches of dark reddish-brown soil overlies the soft, weathered rock. In some places the soil is eroded to soft, weathered rock and, as a result, is grayer or browner than is typical of the Molokai series. There are few to common stones and boulders on the surface. These are unweathered rock cores that have been exposed by erosion. Runoff is rapid, and the erosion hazard is severe. Workability is difficult.

This soil is used for pasture and wildlife habitat. (Capability classification VIe, irrigated or nonirrigated; pasture group 2)

Naiwa Series

This series consists of well-drained soils on uplands on the islands of Lanai, Molokai, and Maui. These soils developed in volcanic ash and material weathered from basic igneous rock. They are gently sloping to moderately steep. Elevations range from 250 to 3,250 feet. The annual rainfall amounts to 35 to 50 inches. The mean annual soil temperature is 70° F.

These soils are used for pasture, woodland, and wildlife habitat. Small acreages on the island of Molokai are used for pineapple. The natural vegetation consists of aalii, guava, kikuyugrass, lantana, and puakeawe.

Naiwa silty clay loam, 3 to 20 percent slopes (NAC).—This soil is on smooth side slopes and intermediate slopes in the uplands. Included in mapping were small areas of Olelo and Oli soils. Also included were small, eroded areas where the surface layer is very thin and where, in some places, the subsoil has been removed by erosion and weathered rock is exposed.

Naiwa soils are geographically associated with Kalae, Olelo, and Oli soils. In a representative profile the surface layer is dusky-red silty clay loam about 11 inches thick. The subsoil, about 30 inches thick, is dark-red, dark reddish-brown, and red silt loam and loam that has subangular blocky structure. The substratum is soft, weathered basic igneous rock. The soil is strongly acid in the surface layer and strongly acid to very strongly acid in the subsoil.

Permeability is moderately rapid. Runoff is medium, and the erosion hazard is moderate to severe. The available water capacity is about 1.2 inches per foot of soil. In places roots penetrate to a depth of 3 feet or more.

Representative profile: Island of Maui, lat. 20°56′58″ N. and long. 156°31′20″ W.

Ap—0 to 4 inches, dusky-red (10R 3/3), moist and dry, silty clay loam; weak, fine, subangular blocky structure; slightly hard, firm, sticky and slightly plastic; many fine roots; many fine and medium pores; common worm casts and worm channels; moderately high bulk density; strongly acid; clear, smooth boundary. 3 to 6 inches thick.

A1—4 to 11 inches, dusky-red (10R 3/4), moist and dry, silty clay loam; moderate and strong, fine and very fine, subangular blocky structure; slightly hard, firm, sticky and plastic; many fine roots; many fine and medium pores; purplish cast when dry; high bulk density; strongly acid; abrupt, smooth boundary. 5 to 9 inches thick.

B1—11 to 14 inches, dark-red (10R 3/6), moist and dry, silt loam; weak, coarse and medium, subangular blocky structure; slightly hard, friable, slightly sticky and plastic; many fine roots; many fine pores; moderate bulk density; strongly acid; clear, wavy boundary. 1 to 5 inches thick.

B2—14 to 26 inches, red (10R 4/6), moist and dry, silt loam; weak, medium and coarse, subangular blocky structure; soft, very friable, nonsticky and slightly plastic, and weakly smeary; many fine roots; many fine pores; common, very fine, highly weathered rock fragments; strongly acid; gradual, wavy boundary. 9 to 15 inches thick.

B3—26 to 40 inches, dark reddish-brown (2.5YR 3/4) loam, reddish brown (2.5YR 4/4) when dry; weak, fine and very fine, subangular blocky structure; soft, friable, nonsticky and nonplastic, and weakly smeary; many fine roots that have a tendency to form horizontal layers; many fine pores; thin, patchy, translucent glaze; few pockets of decomposing rock fragments; very strongly acid; clear, wavy boundary. 11 to 18 inches thick.

C1—40 to 52 inches, dark reddish-brown (5YR 3/4), moist and dry, loam that has pockets of dark-red (10R 3/6), dark-brown (7.5YR 4/2), and very dark grayish-brown (10YR 3/2) decomposing rock par-

ticles; weak, medium, fine and very fine, subangular blocky structure; soft, friable, nonsticky and nonplastic; many fine roots; many fine and medium pores; 35 to 40 percent decomposing rock fragments; very strongly acid; gradual, wavy boundary. 8 to 15 inches thick.

C2—52 to 60 inches, soft, weathered basic igneous rock that encases a few hard cores; contains isolated roots matted in cracks of rocks.

The solum ranges from 30 to 60 inches in thickness. In some areas, especially where the soil is exposed to wetting and drying, the A horizon is massive. The A horizon ranges from 2.5YR to 10R in hue and, in value, from 2 to 3 when moist and from 3 to 4 when dry. The B horizon ranges from 2.5YR to 10R in hue, from 3 to 4 in value, and from 4 to 6 in chroma.

This soil is used for pasture, woodland, and wildlife habitat. Small acreages on Molokai below an elevation of 2,000 feet are used for pineapple. (Capability classification IVe, nonirrigated; pasture group 6; woodland group 5)

Naiwa silty clay loam, 7 to 15 percent slopes, severely eroded (NAC3).—This soil has a profile like that of Naiwa silty clay loam, 3 to 20 percent slopes, except that it is severely eroded. Shallow gullies are common, and about 75 percent of the original surface layer and, in places, part of the subsoil have been removed by erosion. The erosion hazard is severe.

This soil is used for pasture, woodland, and wildlife habitat. (Capability classification VIe, nonirrigated; pasture group 6; woodland group 5)

Niu Series

This series consists of well-drained soils on uplands on the island of Kauai. These soils developed in material weathered from basic igneous rock, possibly mixed with volcanic ash. They are gently sloping to steep. Elevations range from 750 to 1,800 feet. The annual rainfall amounts to 22 to 35 inches, of which 70 percent falls in the period November to April. The mean annual soil temperature is 64° to 71° F. Niu soils are geographically associated with Mahana and Makaweli soils.

These soils are used for irrigated sugarcane, pasture, wildlife habitat, and woodland. The natural vegetation consists of kiawe, lantana, klu, koa haole, aalii, feather fingergrass, piligrass, guineagrass, and indigo.

Niu silty clay loam, 6 to 12 percent slopes (NcC).—This soil is on the tops of ridges in the uplands. Included in mapping were a few small areas where the slope is 2 to 6 percent.

In a representative profile the surface layer is dark reddish-brown silty clay loam about 10 inches thick. The subsoil, about 50 inches thick, is dark-red silty clay loam over silty clay. It has subangular blocky structure. The substratum is soft, weathered rock. The surface layer is medium acid. The subsoil is neutral.

Permeability is moderate. Runoff is medium, and the erosion hazard is moderate. The available water capacity is about 1.4 inches per foot of soil. In places roots penetrate to a depth of 5 feet or more.

Representative profile: Island of Kauai, lat. 22°02′6.7″ N. and long. 159°44′37.5″ W.

Ap—0 to 10 inches, dark reddish-brown (2.5YR 3/4) silty clay loam, dark reddish brown (2.5YR 3/4) when rubbed and when dry; weak, fine, subangular blocky structure; hard, friable, sticky and plastic; plentiful medium, fine, and very fine roots; strong to violent effervescence with hydrogen peroxide; medium acid; abrupt, wavy boundary. 8 to 14 inches thick.

B21—10 to 22 inches, dark-red (2.5YR 3/6) silty clay loam, red (2.5YR 4/6) when dry; weak, prismatic structure; hard, friable, sticky and plastic; plentiful medium, fine, and very fine roots; common medium pores; many fine, very fine, and micro pores; thin, patchy coatings on peds; coatings look like clay films; upper 2 inches compacted by tillage; slight to moderate effervescence with hydrogen peroxide; neutral; gradual, smooth boundary. 8 to 14 inches thick.

B22—22 to 36 inches, dark-red (10R 3/6) light silty clay, dark red (10R 3/6) when dry; weak to moderate, fine and very fine, subangular blocky structure; hard, friable, sticky and plastic; few medium, plentiful fine and very fine roots; few medium, common fine, and many very fine and micro pores; nearly continuous, moderately thick coatings on some peds; coatings look like clay films; compact in place; slight to moderate effervescence with hydrogen peroxide; neutral; gradual, smooth boundary. 12 to 16 inches thick.

B23—36 to 60 inches, dark-red (10R 3/6) silty clay, dark red (10R 3/6) when rubbed, dark red (10R 3/6) when dry; moderate, fine and very fine, subangular blocky structure; hard, friable, sticky and plastic; few medium, fine, and very fine roots; few medium, common fine and very fine pores; continuous, moderately thick coatings on some peds; coatings look like clay films; compact in place; no effervescence with hydrogen peroxide; neutral.

The A horizon ranges from 10R to 2.5YR in hue, from 2 to 3 in value, and from 3 to 4 in chroma. It ranges from silty clay loam to silty clay in texture. The B horizon ranges from 10R to 2.5YR in hue, from 2 to 3 in value, and from 5 to 7 in chroma. The upper part of the B horizon ranges from weak to moderate in structure, and the lower part from moderate to strong. In places small, black concretions occur throughout the profile.

This soil is used for irrigated sugarcane, pasture, wildlife habitat, and woodland. (Capability classification IIIe, irrigated or nonirrigated; sugarcane group 1; pasture group 3; woodland group 1)

Niu silty clay loam, 12 to 20 percent slopes (NcD).—On this soil, runoff is rapid and the erosion hazard is severe.

This soil is used for sugarcane, pasture, wildlife habitat, and woodland. (Capability classification IVe, irrigated or nonirrigated; sugarcane group 1; pasture group 3; woodland group 1)

Niu silty clay loam, 6 to 20 percent slopes, eroded (NcD2).—This soil is similar to Niu silty clay loam, 6 to 12 percent slopes, except that the surface layer and part of the subsoil have been removed by erosion, and there are many gullies. Runoff is rapid, and the erosion hazard is severe.

This soil is used for pasture, wildlife habitat, and woodland. (Capability classification IVe, nonirrigated; sugarcane group 1; pasture group 3; woodland group 1)

Niu silty clay loam, 20 to 35 percent slopes, eroded (NcE2).—This soil is similar to Niu silty clay loam, 6 to 12 percent slopes, except that most of the original surface layer has been removed by erosion. Runoff is rapid, and the erosion hazard is severe.

This soil is used for pasture, wildlife habitat, and woodland. (Capability classification VIe, nonirrigated; pasture group 3; woodland group 1)

Niulii Series

This series consists of well-drained soils on uplands on the island of Molokai. These soils formed in local alluvium and colluvium and were influenced by volcanic ash. They are sloping to hilly. On Molokai, elevations range from 1,250 to 2,000 feet. The annual rainfall amounts to 70 to 90 inches and is fairly well distributed throughout the year. Cloud and fog cover persist throughout most of the day. The mean annual soil temperature is 68° F. Niulii soils are geographically associated with Olokui soils and the medium-textured variant of Niulii soils.

In this survey area a medium-textured variant of the Niulii series was mapped. This soil, Niulii silty clay loam, medium textured variant, 7 to 30 percent slopes, is described in alphabetical order, along with other mapping units of this series.

These soils are used for pasture and wildlife habitat. The natural vegetation consists of carpetgrass, glenwoodgrass, ohia, false staghornfern, treefern, creeping Chinese violets, and sedges.

Niulii silty clay loam, 7 to 30 percent slopes (NIE).—This soil occurs in areas where the topography is sloping to hilly.

In a representative profile the surface layer, about 11 inches thick, is dark-brown silty clay loam and silty clay that has subangular blocky structure. The subsoil, about 13 inches thick, is dark-brown silty clay that has subangular and angular blocky structure. The substratum is soft, highly weathered stones and gravel. The soil is very strongly acid throughout the profile.

Permeability is moderately rapid. Runoff is slow to medium, and the erosion hazard is slight to moderate. In places roots penetrate to a depth of 3 feet or more. Workability is slightly difficult because of the slope.

Representative profile: Island of Molokai, lat. 21°06′56″ N. and long. 156°47′23″ W.

A11—0 to 5 inches, dark-brown (10YR 3/3) silty clay loam, dark gray (10YR 4/1) when dry; strong and moderate, fine, subangular blocky structure; very hard, friable, sticky and plastic; many roots; many interstitial pores; very strongly acid; clear, wavy boundary. 4 to 6 inches thick.

A12—5 to 11 inches, dark-brown (10YR 3/3) silty clay, dark gray (10YR 4/1) when dry; moderate, fine, subangular blocky structure; very hard, friable, sticky and plastic; many roots; many, very fine, tubular pores and common, fine, tubular pores; very strongly acid; clear, wavy boundary. 5 to 8 inches thick.

B22—11 to 24 inches, dark-brown (10YR 3/3) silty clay, dark grayish brown (10YR 4/2) when dry; moderate, fine and medium, subangular and angular blocky structure; slightly hard, friable, sticky and plastic; few roots; many, very fine, tubular pores and common, fine, tubular pores; common oxide coatings on peds; gritty feeling because of few very fine rock fragments; very strongly acid; clear, wavy boundary. 11 to 22 inches.

C—24 to 40 inches, soft, highly weathered stones and pebbles, some of which break down to smeary silty clay loam.

IIR—40 inches, hard pahoehoe lava.

The A horizon is 10YR in hue. The B horizon ranges from 10YR to 7.5YR in hue. In places a few, fine, distinct, reddish-brown mottles occur in the A horizon and few to common, fine, reddish-brown mottles in the B horizon. This soil has a tendency to harden irreversibly upon drying.

This soil is used for pasture and wildlife habitat. (Capability classification VIe, nonirrigated; pasture group 9; woodland group 8)

Niulii silty clay loam, medium textured variant, 7 to 30 percent slopes (NME).—This soil occurs on East Molokai, mainly on narrow ridges bordered by deep gulches. In most places the slope is 15 to 25 percent. Elevations range from 500 to 2,500 feet. The annual rainfall amounts to 40 to 60 inches. In a representative profile the texture of the subsoil is coarser than is typical of the Niulii series, and the structure is weaker.

This soil is dark brown throughout the profile. The surface layer is silty clay loam about 8 inches thick. The subsoil is very friable silt loam, 22 to 27 inches thick. The substratum is soft, weathered rock. The soil is strongly acid throughout the profile.

Permeability is moderately rapid. Runoff is slow to medium, and the erosion hazard is moderate to severe. Workability is slightly difficult to difficult because of the slope. In many places this soil is slightly eroded.

This soil is used mostly for pasture and wildlife habitat. Small areas are used for woodland. (Capability classification VIe, nonirrigated; pasture group 9; woodland group 8)

Nohili Series

This series consists of poorly drained soils on coastal plains on the island of Kauai. These soils developed in alluvium that was deposited over marly lagoon deposits. They are nearly level. Elevations range from nearly sea level to a few feet above sea level. The annual rainfall amounts to 20 to 40 inches. The mean annual soil temperature is 75° F. Nohili soils are geographically associated with Kaloko soils.

These soils are used for irrigated sugarcane. They are all under cultivation.

Nohili clay (Nh).—This soil is on the coastal plains.

In a representative profile the surface layer is dark reddish-brown clay about 18 inches thick. The subsoil, about 15 inches thick, is mottled, dark-brown, very dark gray, and grayish-brown clay that has angular blocky structure. The substratum is marly clay that is underlain in places by dark-gray, noncalcareous clay. The surface layer is mildly alkaline and moderately alkaline.

Permeability is moderately slow. Runoff is slow, and there is no erosion hazard. This soil is subject to occasional flooding. Unless the soil is artificially drained, the water table is within 2 feet of the surface. The available water capacity is about 1.7 inches per foot of soil. In places roots penetrate to the water table. Workability is difficult.

Representative profile: Island of Kauai, lat. 21°59′36.8″ N. and long. 159°44′28.8″ W.

Ap1—0 to 5 inches, dark reddish-brown (5YR 3/2) clay, dark reddish brown (5YR 3/2) when dry; strong, fine and very fine, subangular blocky structure; extremely hard, firm, very sticky and very plastic; no roots; moderate effervescence with hydrogen peroxide; moderate effervescence with hydrochloric acid; mildly alkaline; abrupt, smooth boundary. 4 to 6 inches thick.

Ap2—5 to 18 inches, dark reddish-brown (5YR 3/3) clay, brown (7.5YR 4/2) when dry; moderate, medium, subangular blocky structure; extremely hard, firm,

very sticky and very plastic; plentiful medium and fine roots; common medium and fine pores; moderate effervescence with hydrogen peroxide; slight effervescence with hydrochloric acid; mildly alkaline; abrupt, wavy boundary. 11 to 15 inches thick.

B21—18 to 23 inches, dark-brown (7.5YR 3/2) clay mottled with reddish brown (5YR 4/4) and dark gray (10YR 4/1), dark brown (7.5YR 3/2) when dry; moderate, fine to coarse, angular blocky structure; extremely hard, firm, very sticky and very plastic; plentiful medium roots and few fine and very fine roots; common medium pores and few fine pores; moderate effervescence with hydrogen peroxide; slight effervescence with hydrochloric acid; few, soft, black concretions; mildly alkaline; abrupt, smooth boundary. 4 to 6 inches thick.

B22—23 to 29 inches, very dark gray (10YR 3/1) clay that contains blotches of light gray (10YR 6/1) and specks of dark reddish brown (2.5YR 3/4), very dark gray (10YR 3/1) when dry; moderate, coarse, angular blocky structure; extremely hard, firm, very sticky and very plastic; abundant fine roots, plentiful very fine roots, and few micro roots; many fine pores and common very fine pores; slight effervescence with hydrochloric acid; few pressure cutans and slickensides; moderately alkaline; gradual, smooth boundary. 5 to 7 inches thick.

B3—29 to 33 inches, grayish-brown (10YR 5/2) clay mottled with yellowish brown (10YR 5/4), dark yellowish brown (10YR 4/4), and black (10YR 2/1); gray (10YR 5/1) when dry; moderate, medium and coarse, angular blocky structure; extremely hard, firm, very sticky and very plastic; plentiful medium and fine roots; common medium and fine pores; slight effervescence with hydrogen peroxide; violent effervescence with hydrochloric acid; moderately alkaline; gradual, smooth boundary. 4 to 6 inches thick.

IIC1—33 to 43 inches, light brownish-gray (2.5Y 6/2) cemented layers that contain lenses of clay mottled with brown (7.5YR 5/4) and yellowish brown (10YR 5/4), dark gray (10YR 4/1) and light gray (N 7/0) when dry; laminated; clay in lenses is extremely hard, firm, very sticky and very plastic; few medium, fine, and very fine roots; few medium, fine, and very fine pores; slight effervescence with hydrogen peroxide; violent effervescence with hydrochloric acid; moderately alkaline; abrupt, smooth boundary. 8 to 12 inches thick.

IIIC2—43 to 120 inches, dark-gray (N 4/0) clay that has some coatings of olive brown (2.5Y 4/4), very dark gray (5Y 3/1) when dry; weak, coarse, angular blocky structure; extremely hard, firm, very sticky and very plastic; abundant fine, very fine, and micro roots; many fine, very fine, and micro pores; very slight effervescence with hydrogen peroxide; no effervescence with hydrochloric acid; yellow and white specks are visible under 10-power lens; many fine, white, elongated crystals form on outside of clods when they dry; very strongly acid.

The A horizon ranges from 2 to 3 in chroma. The B2 horizon ranges from 5YR to 10YR in hue, from 1 to 3 in chroma, and from 2 to 3 in value. The B horizon has few to many mottles. The depth to the marl ranges from 20 to 40 inches.

This soil is used for irrigated sugarcane. (Capability classification IIIw if irrigated, Vw if nonirrigated; sugarcane group 3; pasture group 7)

Nonopahu Series

This series consists of moderately well drained soils on uplands on the island of Kauai. These soils developed in material weathered from basic igneous rock relatively high in olivine. They are gently sloping to moderately sloping. Elevations range from nearly sea level to 800 feet. The annual rainfall amounts to 23 to 40 inches. The mean annual soil temperature is 74° F. Nonopahu soils are geographically associated with Makaweli and Waikomo soils.

These soils are used for irrigated sugarcane and pasture. The natural vegetation consists of koa haole, klu, and feather fingergrass.

Nonopahu clay, 2 to 10 percent slopes (NnC).—This soil is on low ridges on uplands. Included in mapping were small areas where the slope is less than 2 percent.

In a representative profile the surface layer is dark grayish-brown clay about 17 inches thick. The next layer, about 48 inches thick, is brown or grayish-brown clay and silty clay that has angular blocky and subangular blocky structure. This soil is underlain by soft, weathered rock. It is mildly alkaline throughout.

Permeability is moderately slow. Runoff is medium, and the erosion hazard is moderate. The available water capacity is about 1.3 inches per foot of soil. In places roots penetrate to a depth of 5 feet or more. Workability is difficult.

Representative profile: Island of Kauai, lat. 21°54′57″ N. and long. 159°37′26.5″ W.

Ap—0 to 17 inches, dark grayish-brown (10YR 4/2) clay, brown (7.5YR 4/2) when dry; moderate, coarse, granular structure; very hard, firm, sticky and plastic; common fine roots; many, medium, interstitial pores and few, medium, tubular pores; common, black concretions 1 millimeter to 5 millimeters in size; pockets of dark yellowish-brown (10YR 4/4) and dark grayish-brown (2.5Y 4/2) clay; moderate effervescence with hydrogen peroxide; mildly alkaline; clear, wavy boundary. 15 to 20 inches thick.

C1—17 to 31 inches, brown (10YR 4/3) clay; pockets (about 40 percent) of mottled dark yellowish brown (10YR 4/4) and dark gray (10YR 4/1); light olive brown (2.5Y 5/4) when dry; weak, coarse, angular blocky structure; very hard, firm, sticky and plastic; many fine roots; few, medium, interstitial pores and many, medium, tubular pores; common concretions less than 2 millimeters in size; few slickensides; moderate effervescence with hydrogen peroxide; mildly alkaline; abrupt, wavy boundary. 12 to 16 inches thick.

C2—31 to 47 inches, grayish-brown (2.5Y 4/2) clay, light olive gray (5Y 6/2) when dry; weak, coarse, angular blocky structure; extremely hard, very firm, very sticky and very plastic; few fine roots; few, medium, tubular pores; common, fine, black, hard concretions; common slickensides; slight effervescence with hydrogen peroxide; mildly alkaline; clear, smooth boundary. 14 to 18 inches thick.

C3—47 to 65 inches, brown (10YR 4/3) silty clay, brown (10YR 5/3) when dry; strong, medium, subangular blocky structure; very hard, firm, sticky and plastic; few fine roots; many interstitial pores; nearly continuous pressure cutans on ped faces; common slickensides; many, medium, black stains on peds; strong effervescence with hydrogen peroxide; mildly alkaline.

In places a few ironstone-gibbsite pebbles occur throughout the profile. The A horizon ranges from 2 to 4 in chroma and from 3 to 4 in value. The C horizon ranges from 10YR to 2.5Y in hue, from 2 to 4 in chroma, and from 4 to 5 in value. Mottles in the C horizon range from few to common. Unless the soil is irrigated, cracks more than 1 centimeter wide and 20 inches or more deep develop in most years.

This soil is used for sugarcane and pasture. (Capability classification IIIe if irrigated, VIe if nonirrigated; sugarcane group 4; pasture group 2)

Nonopahu stony clay, 2 to 12 percent slopes (NoC).—This soil is similar to Nonopahu clay, 2 to 10 percent slopes, except for the stones. The number of stones ranges from few to many. The stones interfere with farming operations. Included in mapping were small areas of rock outcrop.

This soil is used for sugarcane and pasture. (Capability classification IIIe if irrigated, VIe if nonirrigated; sugarcane group 4; pasture group 2)

Oanapuka Series

This series consists of well-drained, very stony soils on low uplands on the island of Maui. These soils developed in volcanic ash and material derived from cinders. They are moderately sloping to moderately steep. Elevations range from 100 to 800 feet. The annual rainfall amounts to 15 to 25 inches, most of which occurs in winter. The mean annual soil temperature is 73° F. Oanapuka soils are geographically associated with Io and Makena soils.

These soils are used for pasture and wildlife habitat. The natural vegetation consists of feather fingergrass, ilima, kiawe, klu, koa haole, lantana, Natal redtop, and pitted beardgrass.

Oanapuka very stony silt loam, 7 to 25 percent slopes (OAD).—This soil is on the lower uplands. Included in mapping were small areas of Io and Makena soils.

In a representative profile the surface layer, about 6 inches thick, is very dark brown and very dark grayish-brown silt loam that has granular and subangular blocky structure. The subsoil, about 9 inches thick, is very dark grayish-brown silt loam that has prismatic structure. The substratum is dark yellowish-brown silt loam, loam, and stone-size Aa lava. The soil is medium acid to slightly acid in the surface layer, neutral in the subsoil, and neutral to mildly alkaline in the substratum.

Permeability is moderately rapid. Runoff is slow, and the erosion hazard is slight to moderate. The available water capacity is about 1.0 inch per foot of soil. In places roots penetrate to a depth of 4 feet or more.

Representative profile: Island of Maui, lat. 20°39′44″ N. and long. 156°25′10″ W.

A11—0 to 2 inches, very dark brown (10YR 2/2) very stony silt loam, dark brown (10YR 3/3) when dry; weak, fine and medium, granular structure; soft, very friable, nonsticky and slightly plastic; abundant fine roots; common fine and very fine pores; 15 to 30 percent stones; slight effervescence with hydrogen peroxide; medium acid; abrupt, smooth boundary. 1 to 3 inches thick.

A12—2 to 6 inches, very dark grayish-brown (10YR 3/2) silt loam, brown (10YR 4/3) when dry; weak, medium and coarse, subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; abundant fine roots; many fine and very fine pores; few, fine, red, weathered cinders; slight effervescence with hydrogen peroxide; slightly acid; clear, smooth boundary. 3 to 6 inches thick.

B2—6 to 15 inches, very dark grayish-brown (10YR 3/2) silt loam, dark brown (7.5YR 3/2) when dry; moderate, medium, prismatic structure; slightly hard, friable, slightly sticky and slightly plastic, and weakly smeary; abundant fine roots; many fine pores; thin, patchy coatings on peds; coatings look like clay films; few, fine, red, weathered cinders; neutral; clear, wavy boundary. 8 to 14 inches thick.

C1—15 to 28 inches, dark yellowish-brown (10YR 3/4) silt loam, yellowish brown (10YR 5/6) when dry; massive; soft, very friable, slightly sticky and slightly plastic; plentiful fine roots; many fine pores; common, fine, red cinders; neutral; gradual, wavy boundary. 10 to 16 inches thick.

C2—28 to 43 inches, dark yellowish-brown (10YR 3/4) loam, yellowish brown (10YR 5/6) when dry; massive; soft, very friable, slightly sticky and nonplastic; plentiful fine roots; many fine and medium pores; common weathered cinders; few hard stones; mildly alkaline; gradual, wavy boundary. 10 to 20 inches thick.

C3—43 to 46 inches, dark yellowish-brown (10YR 3/4) very cobbly loam, yellowish brown (10YR 5/4) when dry; massive; soft, very friable, nonsticky and nonplastic; 50 to 60 percent gravel-size and cobblestone-size Aa lava fragments; common hard cinders; mildly alkaline; clear, wavy boundary. 2 to 4 inches thick.

IIC4—46 to 55 inches, Aa lava that contains very little soil material in voids; the soil material is dark yellowish-brown (10YR 3/4) loam, yellowish brown (10YR 5/4) when dry; massive; soft, very friable, nonsticky and nonplastic; slight effervescence with hydrochloric acid; mildly alkaline.

The depth of the soil ranges from 40 to more than 60 inches. The A horizon ranges from 7.5YR to 10YR in hue, from 2 to 3 in value when moist and from 3 to 4 when dry, and from 3 to 4 in chroma when dry. The B horizon ranges from 7.5YR to 10YR in hue; from 3 to 4 in value, moist or dry; and from 2 to 4 in chroma, moist or dry. The C horizon ranges from loam to silt loam in texture. The depth to free calcium carbonate ranges from 40 to 60 inches.

This soil is used for pasture and wildlife habitat. (Capability classification VIs, nonirrigated; pasture group 2)

Oanapuka extremely stony silt loam, 7 to 25 percent slopes (OED).—This soil is similar to Oanapuka very stony silt loam, 7 to 25 percent slopes, except that stones cover 3 to 15 percent of the surface area. Included in mapping were small areas of rock outcrop.

This soil is used for pasture and wildlife habitat. (Capability classification VIIs, nonirrigated; pasture group 2)

Olelo Series

This series consists of well-drained soils on uplands on the islands of Molokai and Maui. These soils formed in material derived from basic igneous rock. They are gently sloping to moderately sloping. Elevations range from 2,000 to 3,500 feet. In most places rainfall amounts to 40 to 60 inches annually, but it is as much as 80 inches on Maui. The mean annual soil temperature is 63° F. Olelo soils are geographically associated with Kahanui and Naiwa soils.

These soils are used for woodland, pasture, and wildlife habitat. The natural vegetation consists of hilograss, guava, ohia, puakeawe, aalii, false staghornfern, and sweet vernalgrass.

Olelo silty clay, 3 to 15 percent slopes (OFC).—This soil occurs on narrow to broad ridgetops. Included in mapping were small areas on knolls where the slope is as much as 25 percent.

In a representative profile the surface layer, about 10 inches thick, is dark reddish-brown silty clay that has granular structure in the upper 4 inches but is massive below that depth. The subsoil, about 27 inches thick, is dark reddish-brown and dark-red silty clay that has sub-

angular blocky structure. The substratum is soft, weathered rock. The soil is very strongly acid.

Permeability is moderately rapid. Runoff is slow, and the erosion hazard is slight. In places, roots penetrate to a depth of 5 feet or more.

Representative profile: Island of Molokai, lat. 21°08′32″ N. and long. 156°57′33″ W.

A1—0 to 4 inches, dark reddish-brown (5YR 3/2) silty clay, weak red (2.5YR 4/2) when dry; strong, fine to coarse, granular structure; hard, friable, sticky and plastic; many roots; many interstitial pores; high bulk density; many ironstone fragments as much as ½ inch long; very strongly acid; abrupt, smooth boundary. 3 to 6 inches thick.

A3—4 to 10 inches, dark reddish-brown (5YR 3/3) silty clay, weak red (2.5YR 4/2) when dry; massive (breaks to dense clods); very hard, firm, sticky and plastic; few roots; many, very fine, tubular pores; high bulk density; common pebble-size ironstone fragments; very strongly acid; clear, smooth boundary. 5 to 6 inches thick.

B21—10 to 14 inches, dark reddish-brown (2.5YR 3/5) silty clay, reddish brown (2.5YR 4/4) when dry; moderate, fine and medium, subangular blocky structure; hard, firm, very sticky and plastic; few roots; many, very fine, tubular pores; many wormholes and worm casts; very strongly acid; clear, smooth boundary. 3 to 4 inches thick.

B22t—14 to 19 inches, dark-red (2.5YR 3/6) silty clay, dark reddish brown (2.5YR 3/4) and red (2.5YR 4/6) when dry; moderate, medium and thick, platy structure breaking to moderate, fine and medium, subangular blocky; hard, friable, very sticky and very plastic; few roots; many, very fine, tubular pores and common, fine, tubular pores; common, thin, patchy clay films of slightly higher chroma; at the bottom of this horizon is a very thin (⅛-inch) layer of soft material that develops into an ironstone sheet; very strongly acid; abrupt, wavy boundary. 4 to 5 inches thick.

B23t—19 to 37 inches, dark-red (2.5YR 3/6) silty clay, dark reddish brown (2.5YR 3/4) when dry; strong, very fine and fine, subangular blocky structure; hard, friable, very sticky and very plastic; few roots; many, very fine and fine, tubular pores; continuous, moderate to thick clay films on peds; some very fine aggregates persist as hard, earthy lumps and break down after prolonged rubbing; very strongly acid; clear, wavy boundary. 17 to 19 inches thick.

C—37 to 60 inches, dark-gray (10YR 4/1) and dark-brown (7.5YR 3/3) saprolite; breaks down to smeary silty clay and silty clay loam; patchy, dark-red coatings; horizon contains some gray material that resembles halloysite.

Ironstone fragments in the A horizon normally range from few to many, but they do not occur in all places. The A3 horizon is lacking or discontinuous in some places. The A horizon ranges from 2.5YR to 5YR in hue, from 3 to 4 in value when dry, and from 2 to 4 in chroma when moist and 1 to 2 when dry. The B horizon ranges from 2.5YR to 10R in hue. The texture of the B horizon is generally silty clay but ranges to clay.

This soil is used for pasture and woodland. (Capability classification IIIe, nonirrigated; pasture group 8; woodland group 7)

Oli Series

This series consists of well-drained, moderately deep to deep soils on uplands on the islands of Molokai, Maui, and Kauai. These soils developed in volcanic ash deposited over basic igneous rock. They are gently sloping to very steep. Elevations range from 1,000 to 2,250 feet. The annual rainfall amounts to 30 to 40 inches, most of which occurs from November to April. The mean annual soil temperature is 70° F. Oli soils are geographically associated with Mahana and Naiwa soils.

These soils are used for sugarcane, pasture, woodland, and wildlife habitat. The natural vegetation consists of guava, lantana, molassesgrass, bermudagrass, Natal redtop, and aalii.

Oli silt loam, 10 to 30 percent slopes (OME).—This soil occupies uplands that are dissected by many small gulches.

Included in mapping were severely eroded areas and small areas of Naiwa soils, which make up as much as 15 percent of the acreage.

In a representative profile the surface layer, about 13 inches thick, is dark-brown silt loam and loam. The subsoil, about 17 inches thick, is dark-brown silt loam that has prismatic and subangular blocky structure. The substratum is slightly weathered hard rock. The soil is strongly acid to very strongly acid, except that on Maui it is slightly acid to medium acid.

Permeability is moderately rapid. Runoff is medium, and the erosion hazard is moderate to severe. The available water capacity is about 1.5 inches per foot of soil. This soil is easily eroded because it is very friable and powdery. In places roots penetrate to the bedrock. Workability is slightly difficult to difficult.

Representative profile: Island of Molokai, lat. 21°08′37″ N. and long. 157°00′19″ W.

A1—0 to 5 inches, dark-brown (7.5YR 3/2) silt loam, brown (7.5YR 5/3) when dry; weak and moderate, very fine and fine, granular structure; slightly hard, very friable, nonsticky and nonplastic; many roots; many interstitial pores; strongly acid; clear, smooth boundary. 3 to 9 inches thick.

A3—5 to 13 inches, dark-brown (7.5YR 3/2) loam, yellowish brown (10YR 5/4) when dry; weak, fine and very fine, subangular blocky structure; soft, very friable, nonsticky and slightly plastic; many roots; many pores; few pebbles; strongly acid; abrupt, smooth boundary. 7 to 9 inches thick.

B21—13 to 18 inches, dark-brown (7.5YR 3/2) silt loam, brown (10YR 5/3) when dry; weak, coarse, prismatic structure breaking to weak, fine and medium, subangular blocky; soft, very friable, nonsticky and slightly plastic; many roots; many very fine and fine pores; few andesite pebbles; strongly acid; abrupt, smooth boundary. 5 to 6 inches thick.

B22—18 to 21 inches, dark-brown (10YR 3/3) silt loam, brown (10YR 5/3) when dry; weak, medium, subangular blocky structure; soft, friable, slightly sticky and slightly plastic; many roots; many fine and very fine pores; surface of peds, when dry, appears to be coated with a gray material, which disappears upon wetting; very strongly acid; abrupt, smooth boundary. 3 to 5 inches thick.

IIB23—21 to 30 inches, dark-brown (7.5YR 3/2) clay loam, brown (7.5YR 5/2) when dry; strong, fine and very fine, subangular blocky structure; soft, friable, slightly sticky and slightly plastic; roots are concentrated between peds; few very fine and fine pores; many, hard, earthy lumps; very strongly acid; abrupt, wavy boundary. 9 to 12 inches thick.

IIR—30 inches, hard, slightly weathered andesite bedrock.

The volcanic ash overlay is more than 20 inches thick, except that in eroded spots it may be as thin as 12 inches. The solum ranges from 4 to 5 in value and from 2 to 4 in chroma when dry. It is commonly 7.5YR and 10YR in hue. In places the B horizon is 5YR in hue. The texture of the A horizon is dominantly silt loam, but in some places it is loam

or silty clay loam. The texture of the upper part of the B horizon is loam or silt loam.

This soil is used for pasture and wildlife habitat. In most places guava, lantana, and other shrubs are abundant. (Capability classification VIe, nonirrigated; pasture group 6; woodland group 5)

Oli silt loam, 3 to 10 percent slopes (OMB).—This soil occupies smooth slopes on the uplands of West Maui. Runoff is medium, and the erosion hazard is moderate. The soil is slightly acid in the surface layer and medium acid in the subsoil. Included in mapping were small areas of Molokai and Naiwa soils.

This soil is used for pasture and wildlife habitat. (Capability classification IVe, nonirrigated; pasture group 6; woodland group 5)

Oli silt loam, 30 to 70 percent slopes (OMF).—This soil occurs on the sides of gulches. Runoff is very rapid, and the erosion hazard is very severe. The soil is less than 20 inches deep to soft, weathered rock. Rock outcrops are common. Cultivation is impractical.

This soil is used for pasture, woodland, and wildlife habitat. (Capability classification VIIe, nonirrigated; pasture group 6; woodland group 15)

Oli loam, 12 to 20 percent slopes (OID).—This soil occurs on ridges west of the Hanapepe River in the southern and western parts of Kauai. It has a profile like that of Oli silt loam, 10 to 30 percent slopes, except that the texture of the surface layer is loam in most places but ranges from fine sandy loam to clay loam. Included in mapping were small areas of Mahana soils. Runoff is medium, and the erosion hazard is severe.

This soil is mainly in brushy pasture. A small acreage is in sugarcane. (Capability classification IVe, irrigated or nonirrigated; pasture group 6; woodland group 5)

Olinda Series

This series consists of well-drained soils on uplands on the island of Maui. These soils developed in volcanic ash. They are gently sloping to steep. Elevations range from 2,500 to 5,000 feet. The annual rainfall amounts to 40 to 60 inches and is well distributed throughout the year. The mean annual soil temperature is 57° F. Olinda soils are geographically associated with Kaipoioi and Pane soils.

These soils are used for pasture, woodland, and water supply. Small acreages are used for truck crops and orchards. The natural vegetation consists of bermudagrass, brackenfern, eucalyptus, Natal redtop, puakeawe, sweet vernalgrass, and Yorkshire foggrass.

Olinda loam, 12 to 20 percent slopes (OND).—This soil is on smooth, intermediate to high mountain slopes. Included in mapping were small areas of Kaipoioi and Pane soils. In a few places small, eroded spots were included.

In a representative profile the surface layer is dark reddish-brown loam about 6 inches thick. The subsoil, about 5 inches thick, is dark reddish-brown and yellowish-red silty clay loam that has subangular blocky structure. Below this is yellowish-red and reddish-brown silty clay loam and gravelly silty clay loam. This is underlain by slightly weathered basic igneous rock. The soil is slightly acid in the surface layer and subsoil.

Permeability is moderately rapid. Runoff is slow to medium, and the erosion hazard is slight to moderate. The available water capacity is about 2.4 inches per foot in the surface layer and about 1.6 inches per foot in the subsoil. In places roots penetrate to a depth of 3 feet or more.

Representative profile: Island of Maui, lat. 20°48′30″ N. and long. 156°16′50″ W.

Ap—0 to 6 inches, dark reddish-brown (5YR 3/4) loam, reddish brown (5YR 4/4) when dry; moderate, very fine, granular structure; soft, friable, slightly sticky and nonplastic; abundant fine and very fine roots; many very fine pores; strongly magnetic; few, small, highly weathered, red cinders; slightly acid; abrupt, wavy boundary. 5 to 7 inches thick.

B21—6 to 9 inches, dark reddish-brown (5YR 3/4) silty clay loam, reddish brown (5YR 4/4) when dry; moderate, fine and very fine, subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic, and weakly smeary; abundant fine roots; many very fine pores; thin, patchy, gelatinlike coatings on ped surfaces; very slightly magnetic; slightly acid; clear, wavy boundary. 3 to 6 inches thick.

B22—9 to 14 inches, dark reddish-brown (5YR 3/4) silty clay loam, reddish brown (5YR 4/4) when dry; moderate, medium and fine, subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic, and weakly smeary; abundant fine roots; many fine pores; thin, patchy, gelatinlike coatings on ped surfaces; common sand-size aggregates that are resistant to crushing; has gritty feel after continued rubbing; slightly acid; clear, wavy boundary. 4 to 7 inches thick.

B23—14 to 21 inches, yellowish-red (5YR 4/6) silty clay loam, yellowish red (5YR 5/6) and light reddish brown (5YR 6/4) when dry; moderate, fine, subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic, and weakly smeary; abundant fine and medium roots; many fine pores; thin, patchy, gelatinlike coatings on ped surfaces; many sand-size aggregates that are resistant to crushing; slightly acid; clear, wavy boundary. 6 to 9 inches thick.

IIC1—21 to 28 inches, yellowish-red (5YR 5/6) silty clay loam, pinkish gray (5YR 7/2) when dry; moderate, fine and very fine, subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic, and weakly smeary; plentiful fine roots; many fine pores; thin, patchy, gelatinlike coatings on ped surfaces; 5 to 10 percent slightly weathered gray rock fragments; slightly acid; gradual, wavy boundary. 5 to 10 inches thick.

IIC2—28 to 36 inches, reddish-brown (5YR 4/4) gravelly silty clay loam, pinkish white (5YR 8/2) when dry; moderate, very fine, subangular blocky structure; soft, very friable, slightly sticky and slightly plastic, and weakly smeary; few fine roots; common fine pores; 40 to 50 percent slightly weathered gray rock fragments; slightly acid.

IIIR—36 inches, slightly weathered andesite.

The depth to slightly weathered basic igneous rock ranges from 36 to more than 60 inches. A few stones are on the surface in some places. The B horizon ranges from 5YR to 2.5YR in hue, from 3 to 4 in value when moist and 4 to 6 when dry, and from 4 to 6 in chroma when moist or dry.

This soil is used for pasture, woodland, and water supply. (Capability classification IVe, nonirrigated; pasture group 12; woodland group 10)

Olinda loam, 4 to 12 percent slopes (ONC).—On this soil, runoff is slow and the erosion hazard is slight. Included in mapping were small, eroded spots.

This soil is used for truck crops and pasture. Small acreages are used for orchards. (Capability classification IIIe, nonirrigated; pasture group 12; woodland group 10)

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Olinda loam, 20 to 40 percent slopes (ONE).—This soil is subject to frequent fog and cloud cover. Small gullies are common. Runoff is medium to rapid, and the erosion hazard is moderate to severe. Included in mapping were small areas of rock outcrop and small, eroded spots.

This soil is used for pasture. (Capability classification VIe, nonirrigated; pasture group 12; woodland group 10)

Olokui Series

This series consists of shallow, poorly drained soils on uplands near the summit of Molokai. These soils formed in material derived from basic igneous rock. They are gently sloping to hilly. Elevations range from 1,500 to 4,000 feet. The annual rainfall amounts to 75 to more than 150 inches and is fairly well distributed throughout the year. Fog and cloud cover occur throughout most of the day. The mean annual soil temperature is 58° F. Olokui soils are geographically associated with Amalu soils.

These soils are used for watershed and wildlife habitat. The natural vegetation consists of ohia, treefern, false staghornfern, hilograss, and clubmoss (fig. 7).

Olokui silty clay loam, 3 to 30 percent slopes (OOE).—This soil is shallow and poorly drained. The slope range is 3 to 30 percent, but in most places it is 5 to 20 percent.

Olokui soils have a high organic-matter content. In a representative profile they commonly have a mat of plant residue, about 4 inches thick, on the surface. The mineral soil below is mottled, very dark brown and very dark gray silty clay loam 6 to 17 inches thick. A thin ironstone sheet abruptly overlies soft, weathered rock at depths of 6 to 20 inches below the mineral surface. The soft, weathered rock is many feet thick and can be cut easily with a spade. The soil is extremely acid to very strongly acid.

Permeability above the ironstone sheet is moderately rapid, but the ironstone sheet is impervious except where it is fractured. Runoff is slow, but there is considerable seepage above the ironstone. The erosion hazard is slight to moderate. Roots are restricted by the ironstone sheet, and most trees have a flat rooting system. This soil is always wet.

Representative profile: Island of Molokai, lat. 21°07′09″ N. and long. 156°54′37″ W.

O1—4 inches to 0, dark reddish-brown (5YR 3/2) and very dark brown (10YR 2/2) mat of plant residue, mainly roots; little soil material; extremely acid; abrupt, smooth boundary. 1 to 5 inches thick.

A1g—0 to 4 inches, very dark brown (10YR 2/2) silty clay loam; common, fine, faint, dark reddish-brown and dark-gray mottles along cleavage planes and in pores; weak, medium and coarse, subangular blocky structure; friable, slightly sticky and slightly plastic; many roots; many, very fine and fine, tubular pores and common, medium, tubular pores; many glistening specks; extremely acid; abrupt, wavy boundary. 3 to 5 inches thick.

A2g—4 to 11 inches, very dark gray (10YR 3/1) silty clay

Figure 7.—**Treefern and ohia on Olokui silty clay loam. These plants are dominant on this soil.**

loam; many, distinct, medium and coarse, dark reddish-brown mottles along cleavage planes and in pores; moderate, medium and coarse, subangular blocky structure; friable, sticky and plastic; many roots; many very fine and fine pores; many glistening specks; very strongly acid; abrupt, wavy boundary. 3 to 12 inches thick.

Birm—11 to 11½ inches, horizontal ironstone sheet, dark reddish brown (5YR 2/2) when moist; very hard; discontinuous fine cracks; the ironstone sheet has a troweled surface and is laminar. ⅛ to 1 inch thick.

C—11½ to 60 inches, soft, variegated brown and dark reddish-brown saprolite; can be crushed to silt loam that is smeary when wet; common, discontinuous, ironstone sheets, ⅛ to ½ inch thick, oriented vertically as well as horizontally in this horizon. Many feet thick.

The depth to the ironstone sheet from the bottom of the organic horizon ranges from 6 to 20 inches. The ironstone sheet ranges from ⅛ inch to 2 inches in thickness. Commonly, it is weakly developed where the slope is more than 15 percent. The O1 horizon ranges from 10YR to 5YR in hue. The A1g and A2g horizons range from 10YR to 5Y in hue.

This soil supports a thick, rain forest type vegetation and is used primarily for watershed. It provides a habitat for wild pigs, deer, and goats. (Capability classification VIIw, nonirrigated; woodland group 16)

Opihikao Series

This series consists of well-drained, very shallow, organic soils on uplands on the island of Maui. These soils developed in vegetative material. They are gently sloping to moderately steep. Elevations range from nearly sea level to 200 feet. The annual rainfall amounts to 60 to 90 inches. It is well distributed throughout the year. The mean annual soil temperature is 72° F. Opihikao soils are geographically associated with Hana and Malama soils.

These soils are used for pasture and wildlife habitat. The natural vegetation consists of guava, guineagrass, hala, hilograss, kikuyugrass, and ohia.

Opihikao extremely rocky muck, 3 to 25 percent slopes (OPD).—This soil is on smooth side slopes and toe slopes in the uplands. Rock outcrop covers 40 to 60 percent of the acreage. Included in mapping were small areas of Hana and Malama soils.

In a representative profile the surface layer is black muck about 5 inches thick. The substratum is black pahoehoe lava bedrock. The soil is medium acid to strongly acid in the surface layer.

Permeability is rapid. Runoff is slow to medium, and the erosion hazard is slight to moderate.

Representative profile: Island of Maui, lat. 20°47′36″ N. and long. 156°01′12″ W.

1—0 to 5 inches, black (10YR 2/1) muck, very dark gray (10YR 3/1) when dry; moderate, very fine, granular structure when moist and strong, very fine, subangular blocky structure when dry; very hard, friable, nonsticky and nonplastic, and moderately smeary; abundant fine roots; porous; medium acid; abrupt, smooth boundary. 2 to 5 inches thick.

IIR—5 inches +, hard pahoehoe bedrock.

The muck ranges from 2 to 5 inches in thickness over the bedrock. The muck layer ranges from 7.5YR to 10YR in hue.

This soil is used for pasture and wildlife habitat. (Capability classification VIs, nonirrigated; pasture group 9)

Paaiki Series

This series consists of well-drained soils on dissected uplands on the island of Kauai. These soils developed mainly in material weathered from basic igneous rock but partly in volcanic ash and ejecta. They are gently sloping to very steep. Elevations range from 2,900 to 3,500 feet. The annual rainfall amounts to 40 to 60 inches; clouds cover the area on many afternoons. The mean annual soil temperature is 60° F. Paaiki soils are geographically associated with Oli and Kokee soils.

These soils are used for woodland, wildlife habitat, and water supply. The natural vegetation consists of Formosa koa, koa, puakeawe, Boston fern, ohia, aalii, uki, molassesgrass, uki uki, and ricegrass.

Paaiki loam, 6 to 35 percent slopes (PGE).—This soil occurs on narrow ridges in the uplands.

In a representative profile the surface layer, about 9 inches thick, is dark reddish-brown loam and dark-brown silty clay loam. The subsoil, about 41 inches thick, is brown and dark-brown silty clay loam and silty clay that has subangular blocky structure. The substratum is hard saprolite.

Permeability is moderately rapid. Runoff is slow to medium, and the erosion hazard is slight to moderate. Roots penetrate readily to the hard, weathered rock.

Representative profile: Island of Kauai, lat. 22°06′28″ N. and long. 159°41′14″ W.

A11—0 to 3 inches, dark reddish-brown (5YR 3/3) heavy loam, dark reddish brown (5YR 3/4) when rubbed, yellowish red (5YR 3/6) when dry; moderate, very fine, granular structure; soft, friable, sticky and plastic; abundant roots; many pores; moderate effervescence with hydrogen peroxide; medium acid; clear, smooth boundary. 2 to 4 inches thick.

A12—3 to 6 inches, dark reddish-brown (5YR 3/3) loam, dark reddish brown (5YR 3/4) when rubbed, dark reddish brown (5YR 3/4) when dry; weak, very fine, granular structure; slightly hard, very friable, slightly sticky and slightly plastic; abundant roots; many fine pores; slight effervescence with hydrogen peroxide; some small pieces of black charcoal; strongly acid; clear, smooth boundary. 3 to 5 inches thick.

A3—6 to 9 inches, dark-brown (7.5YR 3/4) silty clay loam, dark brown (7.5YR 3/4) when rubbed, brown (7.5YR 4/4) when dry; weak, fine and very fine, subangular blocky structure; slightly hard, friable, sticky and plastic; plentiful roots; many fine pores; slight effervescence with hydrogen peroxide; medium acid; gradual, smooth boundary. 3 to 4 inches thick.

B21—9 to 18 inches, brown (7.5YR 4/4) heavy silty clay loam, reddish brown (5YR 4/4) when dry; weak, fine and very fine, subangular blocky structure; hard, firm, sticky and plastic; few roots; many fine pores; no effervescence with hydrogen peroxide; strongly acid; gradual, smooth boundary. 6 to 10 inches thick.

B22—18 to 35 inches, brown (7.5YR 4/4) light silty clay, reddish brown (5YR 4/4) when dry; moderate, fine and very fine, subangular blocky structure; hard, firm, sticky and plastic; few roots; many pores; yellowish-red, sugarlike coatings in some pores; very strongly acid; gradual, wavy boundary. 10 to 18 inches thick.

B23—35 to 40 inches, brown (7.5YR 4/4) silty clay, strong brown (7.5YR 4/6) when dry; moderate, fine and very fine, subangular blocky structure; very hard, firm, sticky and plastic; few roots; many pores; yellowish-red, sugarlike coatings in most pores and on ped faces; about 25 percent of this layer is weathered pebbles; very strongly acid; abrupt, wavy boundary. 5 to 15 inches thick.

B3&C 40 to 50 inches, hard, weathered rock; soil material in cracks and pores makes up 5 percent of horizon; soil is reddish-brown (5YR 4/4) silty clay loam, strong brown (7.5YR 5/6) when dry; massive; friable, sticky and plastic.

The A1 horizon ranges from 5YR to 7.5YR in hue, from 2 to 4 in chroma, and from 2 to 3 in value. The A1 horizon is loam or silt loam. The B horizon is generally 7.5YR in hue but ranges from 5YR to 10YR. It ranges from 2 to 4 in chroma and from 3 to 4 in value. The depth to hard, weathered rock ranges from 29 to more than 56 inches.

This soil is used for woodland, wildlife habitat, and water supply. (Capability classification VIe, nonirrigated; pasture group 12; woodland group 10)

Paaiki loam, 35 to 70 percent slopes (PGF).—This soil is similar to Paaiki loam, 6 to 35 percent slopes, except that it is very steep. Runoff is rapid, and the erosion hazard is severe.

This soil is used for woodland, wildlife habitat, and water supply. (Capability classification VIIe, nonirrigated; pasture group 12; woodland group 10)

Paaloa Series

This series consists of well-drained soils on uplands on the island of Oahu. These soils developed in old alluvium and residuum derived from basic igneous rock. They are gently to moderately sloping. Elevations range from 1,000 to 1,700 feet. The annual rainfall amounts to 70 to 90 inches and is fairly well distributed throughout the year. The mean annual soil temperature is 70° F. Paaloa soils are geographically associated with Kapaa, Leilehua, and Manana soils.

These soils are used primarily for pasture and sugarcane. Small areas are used for homesites and pineapple. The natural vegetation consists of guava, ohia, ferns, koa, and californiagrass.

Paaloa silty clay, 3 to 12 percent slopes (PaC).—This soil occurs as narrow areas bounded by steep gulches. The slope range is 3 to 12 percent, but in most places it is 3 to 8 percent. The slopes are smooth.

Included in mapping were small areas where the slope is 0 to 3 percent and small areas of Manana and Leilehua soils.

In a representative profile the surface layer, about 17 inches thick, is a mixture of dark-brown and dark reddish-brown silty clay and clay. The subsoil, about 43 inches thick, is dark reddish-brown silty clay and clay that has subangular blocky structure. The substratum is soft, weathered rock. The soil is strongly acid to very strongly acid.

Permeability is moderately rapid. Runoff is slow to medium, and the erosion hazard is slight to moderate. The available water capacity is about 1.2 inches per foot in the surface layer and about 1.4 inches per foot in the subsoil. In places roots penetrate to a depth of 5 feet or more. Workability is slightly difficult because of the slope.

Representative profile: Island of Oahu, lat. 21°36′02″ N. and long. 158°01′30″ W.

Ap—0 to 17 inches, mixture of about equal parts of dark-brown (7.5YR 3/2) and dark reddish-brown (2.5YR 3/3) silty clay and clay, dark brown (7.5YR 4/4) and dark reddish brown (2.5YR 3/4) when dry; strong, fine and very fine, subangular blocky structure; hard, firm, sticky and plastic; abundant roots; few, fine and very fine, tubular and interstitial pores; strongly acid; abrupt, smooth boundary. 15 to 17 inches thick.

B21t—17 to 25 inches, dark reddish-brown (2.5YR 3/4) silty clay, dark red (2.5YR 3/6) when dry; moderate, fine and very fine, subangular blocky structure; hard, friable, sticky and plastic; few roots; root mat caps this horizon; common, fine, tubular pores; dusky-red clay films in pores and moderately thick, nearly continuous clay films on ped faces; strongly acid; clear, wavy boundary. 6 to 9 inches thick.

B22t—25 to 36 inches, dark reddish-brown (2.5YR 3/4), moist and dry, silty clay; moderate, fine and very fine, subangular blocky structure; hard, friable, sticky and plastic; few very fine roots; many, fine and medium, tubular pores; thin, nearly continuous, dark-red clay films in pores and thin, patchy films on ped faces; 30 to 50 percent of this horizon consists of dark reddish-brown saprolite gravel coated with clay films; very strongly acid; clear, wavy boundary. 10 to 12 inches thick.

B23t—36 to 45 inches, dark reddish-brown (2.5YR 3/4) clay, dark red (2.5YR 3/6) when dry; moderate, medium to very fine, subangular blocky structure; hard, firm, sticky and very plastic; few very fine roots; few, very fine and fine, tubular pores; thin, continuous, dark-red clay films in pores and thin, patchy films on ped faces; very strongly acid; clear, smooth boundary. 9 to 11 inches thick.

B24t—45 to 60 inches, dark reddish-brown (2.5YR 3/4) silty clay, dark red (2.5YR 3/6) when dry; moderate, fine and very fine, subangular blocky structure; hard, friable, sticky and very plastic; few very fine roots; common, tubular pores; thin, continuous, dark-red clay films in pores and thin, patchy films on ped faces; very strongly acid.

The amount of saprolite gravel in the Bt horizon ranges from 5 to 50 percent. Chunks of soil, high in content of titanium oxide and 1 to 4 inches in diameter, are common in the A horizon. The A horizon ranges from 2 to 3 in chroma when moist and from 1 to 4 when dry. In cultivated areas it ranges from 7.5YR to 10YR in hue, and chromas are 2 when moist or dry. The B horizon ranges from 2.5YR to 10R in hue, from 3 to 4 in value, and from 3 to 6 in chroma when moist or dry. The Bt horizon ranges from silty clay to clay in texture.

This soil is used primarily for pasture and sugarcane. Small areas are used for pineapple and urban development. Larger areas were formerly used for pineapple, but, because of cool temperatures and high rainfall, most of these areas are now used for other purposes. (Capability classification IIIe, nonirrigated; sugarcane group 2; pasture group 8; woodland group 7)

Paaloa clay, 2 to 12 percent slopes (PbC).—This soil is similar to Paaloa silty clay, 3 to 12 percent slopes, except that the texture is clay throughout the solum. It is grayer than is typical; hues range from 2.5Y to 10YR, particularly at the higher elevations. Included in mapping were small areas where the texture of the surface layer is silty clay.

This soil is used for sugarcane and pasture. (Capability classification IIIe, nonirrigated; sugarcane group 2; pasture group 8; woodland group 7)

Paia Series

This series consists of well-drained soils on uplands on the island of Maui. These soils developed in material weathered from basic igneous rock. They are gently to moderately sloping. Elevations range from nearly sea level to 1,000 feet. The annual rainfall amounts to 25 to 40 inches. The mean annual soil temperature is 73° F.

Paia soils are geographically associated with Haliimaile, Keahua, and Molokai soils.

These soils are used for sugarcane. Small acreages are used for homesites. The natural vegetation consists of ilima, kiawe, lantana, Natal redtop, uhaloa, and yellow foxtail.

Paia silty clay, 3 to 7 percent slopes (PcB).—This soil is on uplands. Included in mapping were small areas of Haliimaile and Molokai soils. Also included were small, nearly level areas.

In a representative profile the surface layer is dark reddish-brown silty clay and clay about 19 inches thick. The subsoil, about 41 inches thick, is dark reddish-brown clay that has angular and subangular blocky structure. The substratum is soft, weathered basic igneous rock. The soil is mildly alkaline in the surface layer and subsoil.

Permeability is moderate. Runoff is slow, and the erosion hazard is slight. The available water capacity is about 1.3 inches per foot in the surface layer and about 1.6 inches per foot in the subsoil. In places roots penetrate to a depth of 4 feet or more.

Representative profile: Island of Maui, lat. 20°55′10″ N. and long. 156°21′10″ W.

Ap1—0 to 11 inches, dark reddish-brown (5YR 3/2) silty clay, dark reddish brown (5YR 3/3) when dry; weak, fine, granular structure; hard, friable, sticky and plastic; abundant fine roots; many fine pores; many coral fragments, ¼ millimeter to 2 millimeters in diameter; few, fine, black concretions; violent effervescence with hydrogen peroxide; mildly alkaline; gradual, wavy boundary. 8 to 15 inches thick.

Ap2—11 to 19 inches, dark reddish-brown (5YR 3/2) clay, dark reddish brown (5YR 3/3) when dry; weak, fine, subangular blocky structure; hard, firm, very sticky and very plastic; abundant roots; many fine and very fine pores; many coral fragments, ¼ millimeter to 2 millimeters in diameter; few, fine, black concretions; violent effervescence with hydrogen peroxide; mildly alkaline; clear, smooth boundary. 6 to 10 inches thick.

B1—19 to 30 inches, dark reddish-brown (5YR 3/3) clay, dark reddish brown (5YR 3/4) when dry; moderate, fine, subangular blocky structure; hard, firm, sticky and plastic; abundant roots that tend to follow the boundary at bottom of horizon; many fine and very fine pores; few to common, fine, black stains; dusky-red and black stains that effervesce violently with hydrogen peroxide; dark reddish-brown stains that effervesce slightly with hydrogen peroxide; mildly alkaline; clear, smooth boundary. 8 to 12 inches thick.

B21—30 to 41 inches, dark reddish-brown (5YR 3/2) clay, dark reddish brown (5YR 3/3) when dry; moderate, fine, angular and subangular blocky structure; hard, friable, sticky and plastic; few fine roots at the top of horizon and none at the bottom; many fine pores; continuous pressure cutans; compact in place; common sand-size aggregates that are resistant to crushing; few to common, black stains; slight effervescence with hydrogen peroxide in matrix and violent effervescence with hydrogen peroxide on black stains; mildly alkaline; clear, smooth boundary. 8 to 14 inches thick.

B22—41 to 53 inches, dark reddish-brown (5YR 3/3) clay, dark reddish brown (5YR 3/4) when dry; moderate, fine, angular and subangular blocky structure; hard, friable, sticky and plastic; many fine pores; continuous pressure cutans; 30 to 40 percent of matrix has black stains that effervesce violently with hydrogen peroxide; mildly alkaline; gradual, wavy boundary. 11 to 15 inches thick.

B23—53 to 60 inches, dark reddish-brown (5YR 3/3) clay, dark reddish brown (5YR 3/4) when dry; moderate, fine, angular and subangular blocky structure; hard, friable, sticky and plastic; many fine pores; mildly alkaline.

The thickness of the solum is more than 40 inches. The A horizon ranges from 5YR to 7.5YR in hue and, when moist, from 2 to 3 in value and from 2 to 3 in chroma. The texture is silty clay or clay. The B horizon ranges from 2 to 3 in value when moist and 3 to 4 when dry, and from 2 to 3 in chroma when moist. The texture ranges from silty clay to clay.

This soil is used for sugarcane. Small acreages are used for homesites. (Capability classification IIe if irrigated, IIIc if nonirrigated; sugarcane group 1; pasture group 3)

Paia silty clay, 7 to 15 percent slopes (PcC).—On this soil, runoff is slow to medium and the erosion hazard is slight to moderate. Included in mapping were small, moderately steep areas.

This soil is used for sugarcane. (Capability classification IIIe, irrigated or nonirrigated; sugarcane group 1; pasture group 3)

Paia silty clay, 7 to 15 percent slopes, eroded (PcC2).—This soil is similar to Paia silty clay, 3 to 7 percent slopes, except that it is eroded. In most of the area, about 50 percent of the original surface layer has been lost. Runoff is medium, and the erosion hazard is moderate to severe. In places roots penetrate to a depth of 3 or 4 feet.

This soil is used for sugarcane. (Capability classification IVe, irrigated or nonirrigated; sugarcane group 1; pasture group 3)

Pakala Series

This series consists of well-drained soils on alluvial fans and bottom lands on the island of Kauai. These soils developed in alluvium. They are nearly level to moderately sloping. Elevations range from nearly sea level to 400 feet. The annual rainfall amounts to 25 to 40 inches. The mean annual soil temperature is 73° to 75° F. Pakala soils are geographically associated with Makaweli soils.

These soils are used for irrigated sugarcane, pasture, truck crops, and homesites. The natural vegetation consists of koa haole, kiawe, bermudagrass, mango, and associated plants.

Pakala clay loam, 0 to 2 percent slopes (PdA).—This soil is on bottom lands and alluvial fans. Included in mapping were small areas where the surface layer is sandy loam.

In a representative profile the surface layer is dark reddish-brown clay loam about 16 inches thick. The next layer, about 6 inches thick, is dark reddish-brown very fine sandy loam that is massive. Below this is stratified alluvium that ranges from sandy loam to clay loam in texture. The surface layer is very strongly acid. Below the surface layer, the soil is medium acid.

Permeability is moderate. Runoff is very slow, and the erosion hazard is no more than slight. This soil is subject to infrequent nondamaging overflow. The available water capacity is about 1.7 inches per foot of soil. In places roots penetrate to a depth of 5 feet or more.

Representative profile: Island of Kauai, lat. 21°56′20.6″ N. and long. 159°38′28.0′ W.

Ap—0 to 16 inches, dark reddish-brown (2.5YR 3/3) clay loam, dark red (2.5YR 3/6) when dry; moist rubbed color is dark reddish brown (5YR 3/3); weak, fine, subangular blocky structure; slightly hard, firm, sticky and plastic; compacted by tillage; plentiful medium, fine, and very fine roots; slight effervescence with hydrogen peroxide; very strongly acid; abrupt, smooth boundary. 15 to 17 inches thick.

AC—16 to 22 inches, dark reddish-brown (2.5YR 3/3) very fine sandy loam, dark reddish brown (5YR 3/4) when dry; massive; slightly hard, very friable, slightly sticky and plastic; plentiful medium and fine roots; common fine pores; slight effervescence with hydrogen peroxide; under hand lens, material appears to be made up of very fine, sand-size particles; medium acid; abrupt, smooth boundary. 5 to 7 inches thick.

C1—22 to 27 inches, very dusky red (10R 2/3) silt loam, dark reddish brown (5YR 3/4) when dry; massive; soft, very friable, nonsticky and slightly plastic, and weakly smeary; plentiful medium and fine roots; common fine pores; very slight effervescence with hydrogen peroxide; many small pieces of charcoal that are very smeary; medium acid; abrupt, smooth boundary. 4 to 6 inches thick.

C2—27 to 60 inches, dusky-red (10R 3/3) silty clay loam, reddish brown (2.5YR 4/4) when dry; massive; slightly hard, very friable, sticky and plastic; few medium and fine roots; many fine pores; slight effervescence with hydrogen peroxide; horizon stratified with a layer of highly weathered gravel and sand at a depth of 44 to 46 inches and, at a depth of 54 inches, with a ½-inch layer of very dusky red (2.5YR 2/2), smeary material; under hand lens, material has appearance of being made up of very fine sand; medium acid.

The A and C horizons range from 10R to 5YR in hue, from 2 to 4 in value, and from 2 to 4 in chroma. The texture of the C horizon ranges from sandy loam to clay loam. Because of stratification, the thickness and texture of the horizons vary greatly within short distances.

This soil is used for sugarcane and pasture. A small acreage is used for truck crops. (Capability classification I if irrigated, IVc if nonirrigated; sugarcane group 1; pasture group 2; woodland group 4)

Pakala clay loam, 2 to 10 percent slopes (PdC).—On this soil, runoff is slow and the erosion hazard is slight.

This soil is used for sugarcane and pasture. (Capability classification IIe if irrigated, IVe if nonirrigated; sugarcane group 1; pasture group 2; woodland group 4)

Pakala extremely stony sandy clay loam, 0 to 12 percent slopes (PHXC).—This soil is similar to Pakala clay loam, 0 to 2 percent slopes, except that it is extremely stony and includes areas where the soil is gently and moderately sloping. Stones make up about 30 percent, by volume, of the subsoil. Runoff is slow, and the erosion hazard is slight.

This soil is used for pasture and woodland. (Capability classification VIIs, nonirrigated; pasture group 2; woodland group 4)

Pamoa Series

This series consists of well-drained soils on uplands on the islands of Molokai, Lanai, and Oahu. These soils formed in fine-textured old alluvium. They are gently sloping to moderately steep. Elevations range from 100 to 1,500 feet. The annual rainfall amounts to 15 to 30 inches, most of which occurs from November to April. The mean annual soil temperature is 72° F. Pamoa soils are geographically associated with Lahaina soils.

These soils are used for pasture and wildlife habitat. The natural vegetation consists of kiawe, ilima, uhaloa, pitted beardgrass, and fuzzy top.

Pamoa silty clay, 5 to 20 percent slopes (PlD).—This soil is gently sloping to moderately steep. Included in mapping were small, eroded areas and small, stony areas.

In a representative profile the surface layer, about 7 inches thick, is dark reddish-brown silty clay that has subangular blocky structure. The subsoil, about 55 inches thick, is dark reddish-brown clay and silty clay that has subangular blocky structure. The clay is very sticky and very plastic when wet but friable when moist. The substratum is soft, weathered rock. The soil is neutral in the surface layer and in the upper part of the subsoil and slightly acid to very strongly acid in the lower part.

Permeability is moderately slow. Runoff is medium, and the erosion hazard is moderate to severe. This soil is susceptible to gullying and piping. The available water capacity is about 1.2 inches per foot of soil. In places roots penetrate to a depth of 5 feet or more. Workability is difficult because of the very sticky and very plastic clay.

Representative profile: Island of Molokai, lat. 21°08′06″ N. and long. 157°10′11″ W.

A1—0 to 7 inches, dark reddish-brown (5YR 3/3), moist and dry, silty clay; dark reddish brown (5YR 3/4) when crushed, moist; moderate, very fine to medium, subangular blocky structure breaking to moderate, fine and medium, granular; hard, friable, sticky and very plastic; many roots; few, thin, patchy coatings on peds; many manganese concretions; violent effervescence with hydrogen peroxide; neutral; gradual, wavy boundary. 6 to 8 inches thick.

B1—7 to 15 inches, dark reddish-brown (5YR 3/4), moist and dry, clay; moderate, very fine and fine, subangular blocky structure; pockets of loose material that has very fine, subangular blocky structure; slightly hard, friable, very sticky and very plastic; many roots; many, very fine and fine, tubular pores; few, thin, patchy coatings on peds; many, fine, black concretions; strong effervescence with hydrogen peroxide; neutral; clear, wavy boundary. 5 to 8 inches thick.

B21—15 to 32 inches, dark reddish-brown (5YR 3/4), moist and dry, silty clay; moderate, very fine to medium, subangular blocky structure; hard, friable, very sticky and very plastic; many roots; many, very fine, tubular pores and common, fine, tubular pores; common organic stains in root channels; many patchy stress cutans; strong effervescence with hydrogen peroxide; firm in place; slightly acid; clear, wavy boundary. 15 to 18 inches thick.

B22—32 to 40 inches, dark reddish-brown (5YR 3/4), moist and dry, clay; strong, very fine and fine, angular and subangular blocky structure; hard, friable, very sticky and very plastic; many roots; many, very fine, tubular pores and common, fine, tubular pores; continuous, weakly grooved stress cutans; firm in place; common organic stains in root channels; strong effervescence with hydrogen peroxide; strongly acid; gradual, wavy boundary. 7 to 9 inches thick.

B23—40 to 62 inches, dark reddish-brown (5YR 3/4), moist and dry, clay; few, fine, distinct, dark-brown mottles along some major root channels; moderate, coarse, subangular blocky structure breaking to moderate and strong, very fine and fine, angular and sub-

angular blocky; hard, friable, very sticky and very plastic; many roots; many, very fine, tubular pores; continuous stress cutans and coatings on peds; many black stains; strong effervescence with hydrogen peroxide; very strongly acid.

Few to many, vertical tubular holes, a few inches to 5 feet in diameter and 2 to 10 feet deep, occur throughout this soil. A strong, granular surface mulch, ½ inch to 2 inches thick, forms upon drying. Cracks, ½ inch to 2 inches wide and several feet deep, occur when the soil is dry. The texture of the solum ranges from clay to silty clay. The profile ranges from 5YR to 2.5YR in hue. The A horizon ranges from 2 to 3 in chroma when moist. The B horizon ranges from 2 to 3 in value when moist and from 3 to 6 in chroma when moist or dry.

This soil is used for pasture and wildlife habitat. It can be used for cultivated crops, but in most places it occurs in association with soils that are poorly suited to cultivation. (Capability classification IVe, nonirrigated; pasture group 3)

Pamoa silty clay, 5 to 20 percent slopes, eroded (PID2).—On this soil, runoff is medium and the erosion hazard is severe. Both sheet and gully erosion are active. In most places about 75 percent of the surface layer has been removed. There are common shallow and moderately deep gullies that have cut into and channeled away part of the subsoil. Workability is difficult. Included in mapping were a few small, stony areas.

This soil is used for pasture and wildlife habitat. (Capability classification VIe, nonirrigated; pasture group 3)

Pamoa stony silty clay, 5 to 20 percent slopes, eroded (PJD2).—This soil has a profile like that of Pamoa silty clay, 5 to 20 percent slopes, except for erosion and stoniness. Runoff is medium, and the erosion hazard is severe. Both sheet erosion and gully erosion are active. Most of the surface layer has been removed, and gullies are common. The gullies are steep sided, and many extend to the bedrock. The gullies and stones make workability difficult.

This soil is used for pasture and wildlife habitat. (Capability classification VIe, nonirrigated; pasture group 3)

Pane Series

This series consists of well-drained soils on uplands on the island of Maui. These soils developed in volcanic ash. They are moderately sloping to moderately steep. Elevations range from 2,000 to 3,500 feet. The annual rainfall amounts to 30 to 50 inches; it is well distributed throughout the year. The mean annual soil temperature is 66° F. Pane soils are geographically associated with Haliimaile, Kaipoioi, and Kula soils.

These soils are used for pasture and wildlife habitat. Small acreages are used for truck crops, pineapple, and homesites. The natural vegetation consists of burclover, dallisgrass, plantain, rattailgrass, vetch, and white clover.

Pane silt loam, 7 to 25 percent slopes (PXD).—This soil is on rough side slopes and intermediate slopes in the uplands. Included in mapping were small areas of Haliimaile and Kaipoioi soils. Also included were small areas of moderately shallow soils and soils that have a gravelly surface layer. In addition, small areas where the topography is undulating were included.

In a representative profile the surface layer is dark reddish-brown silt loam about 8 inches thick. The subsoil, about 49 inches thick, is dark reddish-brown, reddish-brown, and dark-brown silt loam and loam that has prismatic and subangular blocky structure. The substratum is soft, weathered basic igneous rock. The soil is slightly acid in the surface layer and neutral in the subsoil.

Permeability is moderately rapid. Runoff is slow to medium, and the erosion hazard is slight to moderate. The available water capacity is about 1.8 inches per foot in the surface layer and subsoil.

Representative profile: Island of Maui, lat. 20°49′30″ N. and long. 156°18′40″ W.

Ap—0 to 8 inches, dark reddish-brown (5YR 3/3) silt loam, reddish brown (5YR 4/3) when dry; strong, fine and very fine, granular structure; slightly hard, very friable, slightly sticky and slightly plastic, and weakly smeary; abundant fine and very fine roots; many fine pores; slight effervescence with hydrogen peroxide; slightly acid; clear, smooth boundary. 6 to 9 inches thick.

B21—8 to 16 inches, dark reddish-brown (5YR 3/4) silt loam, reddish brown (5YR 4/4) when dry; weak, coarse, prismatic structure; slightly hard, very friable, slightly sticky and slightly plastic, and weakly smeary; abundant fine roots; many fine pores; neutral; clear, smooth boundary. 6 to 9 inches thick.

B22—16 to 29 inches, dark reddish-brown (5YR 3/4) loam, reddish brown (5YR 4/4) when dry; moderate, fine and very fine, subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic, and weakly smeary; abundant fine and medium roots; many fine pores; many sand-size aggregates that are resistant to crushing; 2 to 3 percent gravel; neutral; gradual, irregular boundary. 10 to 15 inches thick.

B23—29 to 39 inches, reddish-brown (5YR 4/4) silt loam, reddish brown (5YR 5/4) when dry; weak, fine and very fine, subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic, and weakly smeary; plentiful fine and medium roots; many fine pores; neutral; clear, wavy boundary. 8 to 11 inches thick.

B3—39 to 57 inches, dark-brown (7.5YR 3/2) gravelly loam, brown (7.5YR 5/4) when dry; weak, fine and very fine, subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic, and weakly smeary; few fine roots; many fine and medium pores; 20 to 30 percent gray, highly weathered, pebble-size rock fragments; neutral; abrupt, wavy boundary. 17 to 19 inches thick.

IIC—57 to 65 inches, brown (10YR 4/3) very gravelly loam, pale brown (10YR 6/3) when dry; weak, fine, subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic, and weakly smeary; few fine roots; many fine pores; 50 to 70 percent strongly weathered, pebble-size and cobblestone-size rock fragments; neutral.

The solum is more than 40 inches thick. A few pebbles, cobblestones, and stones occur on the surface in some areas. The A horizon ranges from 5YR to 10YR in hue and from 2 to 3 in value and chroma when moist. The B horizon ranges from 5YR to 7.5YR in hue; from 3 to 4 in value when moist and 4 to 5 when dry; and from 2 to 4 in chroma, moist or dry. The texture of the B horizon ranges from loam to silty clay loam.

This soil is used for pasture and wildlife habitat. Small acreages are used for truck crops, pineapple, and homesites. (Capability classification IVe, nonirrigated; pasture group 5; woodland group 3)

Papaa Series

This series consists of well-drained soils on uplands on the island of Oahu. These soils formed in colluvium and residuum derived from basalt. They are moderately sloping to very steep. Elevations range from nearly sea level to 500 feet. The annual rainfall amounts to 30 to 45 inches, most of which occurs between November and April. The mean annual soil temperature is 73° F. Papaa soils are geographically associated with Alaeloa and Kokokahi soils, near Kailua.

These soils are used for pasture. The natural vegetation consists of guava, Java plum, klu, koa haole, Christmas berry, lantana, sourgrass, and ricegrass.

Papaa clay, 35 to 70 percent slopes (PYF).—This soil has convex, very steep slopes. Included in mapping were small areas of Alaeloa soils and small, eroded spots. Also included were small, stony areas and basalt outcrops near the ridgetops.

In a representative profile the surface layer is very dark brown clay about 12 inches thick. The next layers are dark reddish-brown and dark reddish-gray clay that has prismatic structure. They extend to a depth of about 24 inches. Below this is clay to silty clay loam that has a variegated color pattern of grays, browns, and yellows. Soft, weathered rock is at a depth of about 40 inches. The clays in this soil are very sticky and very plastic, and they crack widely when dry. The soil is slightly acid throughout the profile.

Permeability is slow. Runoff is rapid, and the erosion hazard is severe. The available water capacity is about 1.4 inches per foot of soil. Roots penetrate to a depth of 40 inches or more.

Representative profile: Island of Oahu, lat. 21°22'04" N. and long. 157°44'11" W.

Ap—0 to 12 inches, very dark brown (10YR 2/2) clay, some dark-brown (7.5YR 4/2) material mixed by churning, very dark gray (10YR 3/1) when dry; moderate, very fine and fine, granular mulch in upper ½ inch to 1 inch and strong, fine, subangular blocky structure below; hard, firm, very sticky and very plastic; abundant fine and medium roots; common, fine and very fine, tubular and interstitial pores; few wormholes and worm casts; common, fine, dark-gray, highly weathered rock fragments; common shiny specks; slight effervescence with hydrogen peroxide; slightly acid; clear, smooth boundary. 6 to 14 inches thick.

AC—12 to 19 inches, dark reddish-brown (5YR 3/2), moist and dry, clay; moderate, coarse, prismatic structure; hard, firm, very sticky and very plastic; abundant fine and medium roots; many, very fine, tubular pores and few, fine, tubular pores; common wormholes and worm casts that are thickly coated with very dark gray gelatinous material; few, fine, angular rock fragments; slight effervescence with hydrogen peroxide; slightly acid; clear, smooth boundary. 6 to 9 inches thick.

C1—19 to 24 inches, dark reddish-gray (5YR 4/2), moist and dry, clay; weak, coarse, prismatic structure; hard, very firm, very sticky and very plastic; abundant fine and medium roots; common, very fine and fine, tubular pores; root channels lined with very dark gray material; common prominent slickensides; few fine rock fragments; slight effervescence with hydrogen peroxide; slightly acid; abrupt, wavy boundary. 4 to 8 inches thick.

C2—24 to 28 inches, variegated color pattern of grayish-brown (10YR 5/2) and dark grayish-brown (10YR 4/2) clay; strong, coarse, prismatic structure; extremely hard, firm, very sticky and very plastic; abundant fine and medium roots; common fine and medium pores; peds coated with shiny specks; many thick, deeply grooved slickensides; slightly acid; abrupt, wavy boundary. 2 to 10 inches thick.

C3—28 to 40 inches, mixture of brown (10YR 5/3), dark yellowish-brown (10YR 4/4), and dark grayish-brown (10YR 4/2) silty clay loam; massive; slightly hard, friable, slightly sticky and slightly plastic; plentiful fine and medium roots; common, fine, tubular pores; few, fine, highly weathered rock fragments; slightly acid.

C4—40 inches, slightly to moderately weathered basalt.

The depth to bedrock is more than 40 inches. The amount of stones in the profile ranges from 5 to 40 percent. The A horizon ranges from 5YR to 10YR in hue and from 2 to 3 in value when moist. The AC and C horizons range from 10YR to 5YR in hue.

This soil is used for pasture. (Capability classification VIIe, nonirrigated; pasture group 3; woodland group 1)

Papaa clay, 6 to 20 percent slopes (PYD).—On this soil, runoff is slow to medium and the erosion hazard is slight to moderate. Workability is difficult.

This soil is used for pasture. (Capability classification IVe, nonirrigated; pasture group 3; woodland group 1)

Papaa clay, 20 to 35 percent slopes (PYE).—On this soil, runoff is medium to rapid and the erosion hazard is moderate to severe. Workability is difficult.

This soil is used for pasture. (Capability classification VIe, nonirrigated; pasture group 3; woodland group 1)

Paumalu Series

This series consists of well-drained silty clay soils on uplands in the northern part of Oahu. These soils developed in old alluvium and colluvium derived from basic igneous rock. They are gently sloping to very steep. Elevations range from 700 to 1,000 feet. The annual rainfall amounts to 50 to 70 inches and is well distributed throughout the year. The mean annual soil temperature is 71° F. Paumalu soils are geographically associated with Kemoo soils, near Kahuku.

These soils are used for pasture and sugarcane. The natural vegetation consists of guava, waiwe, Christmas berry, ricegrass, and carpetgrass.

Paumalu silty clay, 15 to 25 percent slopes (PeD).—This soil occurs as small, irregularly shaped areas. Included in mapping were small, eroded areas.

In a representative profile the surface layer and the subsoil are dark reddish-brown silty clay that has subangular and angular blocky structure. The surface layer is about 9 inches thick, and the subsoil is 30 to more than 60 inches thick. The substratum is highly weathered gravel. The soil is very strongly acid in the surface layer and strongly acid to medium acid in the subsoil.

Permeability is moderately rapid. Runoff is medium, and the erosion hazard is moderate. The available water capacity is about 1.3 inches per foot of soil. In places roots penetrate to a depth of 5 feet or more. Workability is difficult because of the slope.

Representative profile: Island of Oahu, lat. 21°40'18" N. and long. 158°01'02" W.

A1—0 to 9 inches, dark reddish-brown (5YR 3/3) silty clay, reddish brown (5YR 4/3) when dry; strong, fine, subangular blocky structure; hard, firm, sticky and plastic; abundant fine and medium roots; many, very fine and fine, interstitial and tubular pores; few highly weathered pebbles; very strongly acid; abrupt, smooth boundary. 8 to 12 inches thick.

B21—9 to 17 inches, dark reddish-brown (5YR 3/4) silty clay, reddish brown (5YR 4/4) when dry; moderate, fine, subangular blocky structure; hard, firm, sticky and plastic; abundant fine roots; common, fine and very fine, tubular pores; few highly weathered pebbles; common black stains; strongly acid; clear, smooth boundary. 5 to 9 inches thick.

B22t—17 to 33 inches, dark reddish-brown (5YR 3/4) silty clay, reddish brown (5YR 4/4) when dry; moderate, very fine and fine, angular and subangular blocky structure; hard, firm, sticky and plastic; few very fine roots; common, very fine, tubular pores; common black stains; thin, continuous clay films on peds and in pores; few highly weathered pebbles; medium acid; gradual, smooth boundary. 10 to 16 inches thick.

B31t—33 to 48 inches, dark reddish-brown (5YR 3/4) silty clay, reddish brown (5YR 4/4) when dry; strong, fine, blocky structure; few fine roots; few, fine, tubular pores; thin, continuous, dark-red (2.5YR 3/6) clay films on peds and in pores; common highly weathered pebbles; medium acid; clear, wavy boundary. 12 to 15 inches thick.

B32—48 to 70 inches, dark reddish-brown (5YR 3/4) silty clay, reddish brown (5YR 4/4) when dry; strong, fine, blocky structure; few, fine, tubular pores; thin, continuous, dark-red (2.5YR 3/6) clay films on peds and in pores; 40 to 50 percent highly weathered gravel; medium acid; clear, wavy boundary.

The depth to highly weathered gravel ranges from 30 to more than 60 inches. The B horizon ranges from 3 to 4 in value when moist and from 4 to 6 in chroma, moist or dry. Effervescence with hydrogen peroxide ranges from none to moderate in the A horizon.

This soil is used for pasture and sugarcane. (Capability classification IVe, irrigated or nonirrigated; pasture group 8; woodland group 7)

Paumalu silty clay, 3 to 8 percent slopes (PeB).—On this soil, runoff is slow and the erosion hazard is slight. Workability is easy.

This soil is used for sugarcane and pasture. (Capability classification IIe, irrigated or nonirrigated; pasture group 8; woodland group 7)

Paumalu silty clay, 8 to 15 percent slopes (PeC).—On this soil, runoff is slow to medium and the erosion hazard is slight to moderate. Workability is slightly difficult.

This soil is used for sugarcane and pasture. (Capability classification IIIe, irrigated or nonirrigated; pasture group 8; woodland group 7)

Paumalu silty clay, 25 to 40 percent slopes (PeE).—On this soil, runoff is medium to rapid and the erosion hazard is moderate to severe.

This soil is used for pasture and sugarcane. (Capability classification VIe, irrigated or nonirrigated; pasture group 8; woodland group 7)

Paumalu silty clay, 40 to 70 percent slopes (PeF).—On this soil, runoff is rapid and the erosion hazard is severe.

This soil is used for pasture. (Capability classification VIIe, nonirrigated; pasture group 8; woodland group 14)

Paumalu-Badland complex (PZ).—In this complex Paumalu soils make up 40 to 80 percent of the acreage. The slope is 10 to 70 percent.

The Paumalu soils are similar to Paumalu silty clay, 15 to 25 percent slopes, except for the slope. Runoff is medium to rapid, and the erosion hazard is moderate to severe.

Badland consists of nearly barren land that has remained after the Paumalu soils were removed by wind and water erosion. Runoff is rapid, and the erosion hazard is very severe. About 80 percent of the Badland part occurs in the direction of the trade winds. Rock outcrop, Stony land, Stony steep land, and Rock land were included in mapping, and they make up as much as 25 percent of the area.

This complex is used for pasture and military purposes. (Paumalu part is in capability classification VIIe, nonirrigated; pasture group 8; woodland group 7. Badland part is in capability classification VIIIe, nonirrigated)

Pauwela Series

This series consists of well-drained soils on uplands on the island of Maui. These soils developed in material weathered from basic igneous rock. They are gently sloping to moderately steep. Elevations range from 150 to 1,500 feet. The annual rainfall amounts to 70 to 120 inches; it is well distributed throughout the year. The mean annual soil temperature is 70° F. Pauwela soils are geographically associated with Haiku and Kailua soils.

These soils are used for pasture and water supply. Small acreages are used for pineapple and woodland. The natural vegetation consists of californiagrass, guava, and ricegrass.

Pauwela clay, 3 to 7 percent slopes (PfB).—This soil is on smooth uplands. Included in mapping were small areas of Haiku and Kailua soils.

In a representative profile the surface layer is dark grayish-brown clay about 12 inches thick. The subsoil, about 21 inches thick, is dark reddish-brown clay that has angular blocky and subangular blocky structure. The substratum is soft, weathered basic igneous rock. The soil is very strongly acid to extremely acid in the surface layer and subsoil.

Permeability is moderately rapid. Runoff is slow, and the erosion hazard is slight. The available water capacity is about 1.3 inches per foot of soil. In places roots penetrate to a depth of 3 feet or more.

Representative profile: Island of Maui, lat. 20°55′26″ N. and long. 156°16′24″ W.

Ap1—0 to 6 inches, dark grayish-brown (2.5Y 4/2) clay, grayish brown (2.5Y 5/2) when dry; moderate, fine, subangular blocky structure; hard, firm, sticky and plastic; abundant very fine and fine roots; many fine pores; common sand-size aggregates that are resistant to crushing; many, very fine, glistening specks; high bulk density; few yellowish-red (5YR 4/6) particles from the upper part of the B horizon mixed in by plowing; slight effervescence with hydrogen peroxide; very strongly acid; clear, wavy boundary. 4 to 7 inches thick.

Ap2—6 to 12 inches, dark grayish-brown (2.5Y 4/2) clay, grayish brown (2.5Y 5/2) when dry; moderate, fine, subangular blocky structure; hard, firm, sticky and plastic; abundant very fine and fine roots; many fine pores; common sand-size aggregates that are resistant to crushing; many, very fine, glistening specks; high bulk density; few yellowish-red (5YR 4/6) particles from the upper part of the B horizon mixed in by plowing; slight effervescence with hydrogen

peroxide; few small pockets of very dark brown (10YR 2/2) and black (10YR 2/1), massive, heavy mineral concentration; extremely acid; abrupt, wavy boundary. 5 to 7 inches thick.

B21t—12 to 17 inches, dark reddish-brown (5YR 3/3) clay, reddish brown (5YR 4/4) when dry; moderate, very fine and fine, subangular blocky structure; slightly hard, friable, sticky and plastic; few very fine roots; many, very fine and fine, tubular pores; many sand-size aggregates that are resistant to crushing; moderately thick, patchy clay films; slight effervescence with hydrogen peroxide; extremely acid; gradual, wavy boundary. 4 to 6 inches thick.

B22t—17 to 25 inches, dark reddish-brown (5YR 3/4) clay, reddish brown (5YR 4/4) when dry; strong, fine and very fine, angular blocky structure; hard, firm, sticky and plastic; few very fine roots; common, fine, tubular pores and few, medium, tubular pores; nearly continuous, moderately thick clay films; common, very fine, yellowish-red (5YR 4/6) and brown (7.5YR 4/4) crumbs on some peds; common sand-size aggregates that are resistant to crushing; more compact than the B21t horizon; contains a few yellowish-red sheets, 2 to 10 millimeters thick; slight effervescence with hydrogen peroxide; very strongly acid; clear, wavy boundary. 6 to 10 inches thick.

B23t—25 to 33 inches, dark reddish-brown (5YR 3/4) clay, reddish brown (5YR 4/4) when dry; strong, very fine and fine, angular blocky structure; hard, firm, sticky and plastic; few very fine roots; common, very fine and fine, tubular pores; nearly continuous, moderately thick clay films; common, very fine, yellowish-red (5YR 4/6) and brown (7.5YR 4/4) crumbs on some peds; common sand-size aggregates that are resistant to crushing; few, fine, very dark brown (10YR 2/2), weathered basic igneous pebbles; a few yellowish-red (5YR 4/6) silty clay sheets (1/4 inch to 1 1/4 inches thick) that have weak, subangular blocky structure and a few roots matted on the surface; slight effervescence with hydrogen peroxide; very strongly acid; gradual, wavy boundary. 6 to 9 inches thick.

C1—33 to 42 inches, strong-brown (7.5YR 5/6) and yellowish-red (5YR 4/6) silty clay, reddish yellow (7.5YR 6/6) and yellowish red (5YR 5/6) when dry; moderate, fine and very fine, subangular and angular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; 70 to 90 percent of horizon consists of very dark brown (10YR 2/2), highly weathered basic igneous rock; few veins and sheets of soft gibbsite, 1/16 to 1/4 inch thick; slight effervescence with hydrogen peroxide; very strongly acid; gradual, wavy boundary. 7 to 12 inches thick.

C2—42 to 54 inches, strong-brown (7.5YR 5/6) silty clay, reddish yellow (7.5YR 6/6) when dry; weak, fine and very fine, subangular blocky structure; soft, friable, slightly sticky and slightly plastic; many, very fine, tubular pores; 80 to 95 percent of horizon consists of highly weathered basic igneous rock; common veins of soft gibbsite, 1/16 to 1/4 inch thick; very strongly acid.

The depth to soft, weathered rock ranges from 30 to more than 60 inches. The A horizon ranges from 10YR to 2.5Y in hue, from 3 to 4 in value when moist, and from 2 to 4 in chroma when dry. The B horizon ranges from 5YR to 7.5YR in hue, from 3 to 4 in value when moist and 4 to 6 when dry, and from 3 to 5 in chroma when moist and 4 to 6 when dry. The texture is silty clay or clay.

This soil is used for pasture and water supply. Small acreages are used for pineapple and woodland. (Capability classification IIe, nonirrigated; pineapple group 7; pasture group 8; woodland group 7)

Pauwela clay, 7 to 15 percent slopes (PfC).—On this soil, runoff is slow to medium and the erosion hazard is slight to moderate.

This soil is used for pasture and water supply. Small acreages are used for woodland. (Capability classification IIIe, nonirrigated; pineapple group 8; pasture group 8; woodland group 7)

Pauwela clay, 15 to 25 percent slopes (PfD).—On this soil, runoff is medium and the erosion hazard is moderate. Included in mapping were areas that are steep and moderately eroded. This soil is used for pasture and woodland. (Capability classification IVe, nonirrigated; pineapple group 8; pasture group 8; woodland group 7)

Pearl Harbor Series

This series consists of very poorly drained soils on nearly level coastal plains on the island of Oahu. These soils developed in alluvium overlying organic material. Elevations range from nearly sea level to 5 feet. The annual rainfall amounts to 18 to 40 inches. The mean annual soil temperature is 74° F. Pearl Harbor soils are geographically associated with Hanalei, Kaloko, and Keaau soils.

These soils are used for taro, sugarcane, and pasture. The natural vegetation consists of cattails, mangrove trees, californiagrass, and sedges.

Pearl Harbor clay (Ph).—This soil is on low coastal plains adjacent to the ocean. It is level or nearly level. Included in mapping were small areas of Kaloko and Keaau soils.

In a representative profile the surface layer is very dark gray, mottled clay about 12 inches thick. The subsoil, about 19 inches thick, is very dark gray and very dark grayish-brown, mottled clay that has angular and subangular blocky structure. The substratum is muck or peat. The soil is neutral in the surface layer and mildly to moderately alkaline in the subsoil.

Permeability is very slow. Runoff is very slow to ponded, and the erosion hazard is no more than slight. The available water capacity is about 1.4 inches per foot in the surface layer and subsoil. In places roots penetrate to a depth of 2 to 4 feet. Workability is very difficult.

Representative profile: Island of Oahu, lat. 21°22′19″ N. and long. 158°01′47″ W.

Ap—0 to 12 inches, very dark gray (10YR 3/1) clay; many, fine, strong-brown (7.5YR 5/6), prominent mottles on peds and in pores; dark gray (10YR 4/1) when dry; strong, fine and medium, granular structure and fine, subangular blocky; very hard, firm, very sticky and very plastic; abundant very fine and fine roots; common, very fine and fine, tubular pores and few, medium, tubular pores; common wormholes and worm casts; moderate effervescence with hydrogen peroxide; neutral; clear, wavy boundary. 8 to 12 inches thick.

B21g—12 to 20 inches, very dark gray (10YR 3/1) clay; many strong-brown (7.5YR 5/6) mottles in all pores and a few on ped faces; strong, fine and medium, subangular blocky and angular blocky structure; very hard, firm, very sticky and very plastic; abundant very fine and fine roots; common, very fine and fine, tubular pores and few, medium, tubular pores; thin, intermittent, horizontal layers of ironstone; moderate effervescence with hydrogen peroxide; mildly alkaline; gradual, smooth boundary. 6 to 8 inches thick.

B22g—20 to 25 inches, very dark gray (10YR 3/1) clay; fine pores are lined with strong-brown (7.5YR 5/6) mottles; moderate, fine and medium, subangular blocky structure; hard, firm, sticky and plastic; abundant

very fine roots; many, very fine, tubular pores and common, fine, tubular pores; slight effervescence with hydrogen peroxide; few fine shells that effervesce with hydrochloric acid; moderately alkaline; gradual, smooth boundary. 3 to 7 inches thick.

B23g—25 to 31 inches, very dark grayish-brown (10YR 3/2) clay; many, fine, strong-brown (7.5YR 5/6) mottles in pores and on ped surfaces, grayish brown (10YR 5/2) when dry; moderate, fine and medium, subangular blocky structure; hard, firm, very sticky and very plastic; few very fine roots; many, very fine, tubular pores; few, fine and coarse, tubular pores; wormholes and worm casts; many small shells; strong effervescence with hydrogen peroxide; moderate effervescence with hydrochloric acid on soil mass; violent effervescence on shells; moderately alkaline; abrupt, smooth boundary. 3 to 6 inches thick.

1b—31 to 37 inches, very dark grayish-brown muck; few, fine, strong-brown (7.5YR 5/6) mottles; massive; very hard, friable, slightly sticky and slightly plastic; plentiful roots; common, fine, tubular pores; few shells; few, fine, black fragments of tuff; thin, discontinuous, vertical bands of ironstone; moderate effervescence with hydrogen peroxide; strong effervescence with hydrochloric acid; mildly alkaline; clear, smooth boundary. 4 to 6 inches thick.

2b—37 to 48 inches, very dark gray (10YR 3/1) muck, gray (10YR 6/1) when dry; massive; hard, friable, sticky and plastic; few roots; few, very fine, tubular pores; brackish water table at a depth of 40 inches; few rounded pebbles; mildly alkaline.

The depth to the buried muck or peat ranges from 20 to 33 inches. The brackish water table is at approximately the same depth. In places as much as 5 percent of the buried horizons is coral sand or shells. The solum ranges from 7.5YR to 10YR in hue and from 2 to 4 in value when moist. When dry, the A and B horizons range from 4 to 6 in value and from 0 to 1 in chroma.

This soil is used for sugarcane, taro, bananas, and pasture. (Capability classification IVw, irrigated or nonirrigated; pasture group 7; woodland group 4)

Pohakupu Series

This series consists of well-drained soils on terraces and alluvial fans on the islands of Oahu and Kauai. These soils formed in old alluvium derived from basic igneous material. They are nearly level to moderately sloping. Elevations range from 50 to 250 feet. The annual rainfall amounts to 40 to 60 inches. The mean annual soil temperature is 73° F. Pohakupu soils are geographically associated with Alaeloa, Papaa, and Lihue soils.

These soils are used for sugarcane, pineapple, truck crops, pasture, and homesites. The natural vegetation consists of guava, Christmas berry, Japanese tea, koa haole, and kikuyugrass.

Pohakupu silty clay loam, 0 to 8 percent slopes (PkB).—This soil has smooth slopes and occurs on terraces and alluvial fans. The slopes are mainly 3 to 8 percent. Included in mapping were small areas of Alaeloa and Waialua soils and small areas where the slope is as much as 15 percent. Also included on Kauai were small areas where the texture is silty clay and small areas that have a hue of 2.5YR in the subsoil.

In a representative profile the surface layer is dark reddish-brown silty clay loam about 13 inches thick. The subsoil, 40 to more than 60 inches thick, is dark reddish-brown and dark-brown silty clay loam that has angular and subangular blocky structure. The substratum is strongly weathered gravel. The soil is slightly acid to medium acid.

Permeability is moderately rapid. Runoff is slow, and the erosion hazard is slight. The available water capacity is about 1.5 inches per foot of soil. In places roots penetrate to a depth of 5 feet or more.

Representative profile: Island of Oahu, lat. 21°22′53″ N. and long. 157°45′16″ W.

Ap—0 to 13 inches, dark reddish-brown (5YR 3/3) silty clay loam, reddish brown (5YR 4/3) when dry; strong, very fine, subangular blocky structure; hard, friable, sticky and plastic; abundant roots; many very fine and fine pores; common wormholes and worm casts; moderate effervescence with hydrogen peroxide; slightly acid; abrupt, smooth boundary. 8 to 13 inches thick.

B21—13 to 21 inches, dark reddish-brown (5YR 3/3) silty clay loam, reddish brown (5YR 4/4) when dry; moderate, very fine, subangular blocky structure; hard, friable, slightly sticky and plastic; abundant roots; many, very fine and fine, tubular pores; common, patchy pressure cutans; slight effervescence with hydrogen peroxide; slightly acid; abrupt, smooth boundary. 4 to 9 inches thick.

B22—21 to 38 inches, dark-brown (7.5YR 3/4) silty clay loam, brown (7.5YR 4/4) when dry; strong, very fine, blocky and subangular blocky structure; hard, friable, sticky and plastic; plentiful roots; many, very fine and fine, tubular pores; continuous pressure cutans on ped surfaces; few highly weathered pebbles; many black stains in pores and on peds; stains show strong effervescence with hydrogen peroxide; slightly acid; clear, irregular boundary. 4 to 17 inches thick.

B23—38 to 50 inches, dark-brown (7.5YR 3/4) silty clay loam, brown (7.5YR 4/4) when dry; strong, very fine, angular and subangular blocky structure; hard, friable, sticky and plastic; few roots; many, very fine and fine, tubular pores; strong, continuous pressure cutans; few highly weathered pebbles; common black stains that effervesce with hydrogen peroxide; slightly acid; clear, irregular boundary. 12 to 20 inches thick.

B3—50 to 76 inches, dark-brown (7.5YR 3/4) silty clay loam, brown (7.5YR 4/4) when dry; strong, very fine, angular and subangular blocky structure; hard, friable, slightly sticky and plastic; few roots; many, very fine and fine, tubular pores; nearly continuous pressure cutans; few highly weathered pebbles; few, fine, black stains that effervesce with hydrogen peroxide; slightly acid.

Effervescence with hydrogen peroxide ranges from slight to moderate in the upper part of the profile and from slight to none below. The structure in the B horizon ranges from moderate to strong. In places a few boulder cores occur within the lower part of the profile. The A horizon ranges from 2 to 3 in chroma and value when moist. The B horizon ranges from 7.5YR to 5YR in hue and from 3 to 4 in chroma and value when moist.

This soil is used for pasture, truck crops, and homesites on Oahu and for sugarcane and pineapple on Kauai. (Capability classification IIe if irrigated, IIIe if nonirrigated; sugarcane group 1; pasture group 6; woodland group 5)

Pohakupu silty clay loam, 8 to 15 percent slopes (PkC).—On this soil, runoff is slow to medium and the erosion hazard is slight to moderate. Workability is slightly difficult because of the slope.

Included in mapping were small areas where the surface layer and part of the subsoil have been removed. Also included, near the drainageways, were areas where the slope ranges from 15 to 25 percent.

This soil is used for pasture. (Capability classification IIIe, nonirrigated; sugarcane group 1; pasture group 6; woodland group 5)

Pooku Series

This series consists of well-drained soils on uplands on the island of Kauai. These soils developed in material weathered from basic igneous rock. They are nearly level to steep. Elevations range from 250 to 1,000 feet. The annual rainfall amounts to 80 to 150 inches. The mean annual soil temperature is 72° F. Pooku soils are geographically associated with Makapili soils.

These soils are used for pasture, sugarcane, wildlife habitat, and water supply. The natural vegetation consists of kikuyugrass, pangolagrass, guava, joee, sensitiveplant, ricegrass, yellow foxtail, Java plum, and associated plants.

Pooku silty clay, 0 to 8 percent slopes (PmB).—This soil is on the tops of broad interfluves in the uplands. Included in mapping were about 60 acres east of Anini Stream. The included soil has a yellowish-brown subsoil.

In a representative profile the surface layer is dark-brown silty clay about 14 inches thick. The subsoil, about 48 inches thick, is dark-red and dark reddish-brown silty clay that has subangular blocky structure. The substratum is soft, weathered rock. The soil is strongly acid to extremely acid throughout the profile.

Permeability is moderately rapid. Runoff is slow, and the erosion hazard is no more than slight. In places roots penetrate to a depth of 5 feet or more.

Representative profile: Island of Kauai, lat. 22°12′23.1″ N. and long. 159°29′53″ W.

Ap1—0 to 11 inches, dark-brown (10YR 4/3) silty clay, yellowish brown (10YR 5/4) when dry; strong, very fine, subangular blocky structure; hard, friable, sticky and plastic; abundant roots; many very fine and fine pores; many ironstone-gibbsite pebbles that have a dense outer shell and a softer, yellowish center; extremely acid; clear, smooth boundary. 10 to 15 inches thick.

Ap2—11 to 14 inches, dark-brown (10YR 4/3) silty clay, dark reddish brown (2.5YR 3/4) when mixed by cultivation, yellowish brown (10YR 5/4) and dark reddish brown (2.5YR 3/4) when dry; moderate, very fine, subangular blocky structure; hard, friable, sticky and plastic; medium acid; abrupt, wavy boundary. 3 to 5 inches thick.

B21—14 to 28 inches, dark reddish-brown (2.5YR 3/4) silty clay loam, dark red (2.5YR 3/6) when dry; moderate, very fine, subangular blocky structure; hard, friable, sticky and plastic; abundant fine roots; many very fine and fine pores; nearly continuous pressure cutans; few cutans that look like illuviated sesquioxides; few nonmagnetic, very firm particles that appear to be segregated iron; strongly acid; abrupt, smooth boundary. 10 to 15 inches thick.

B22—28 to 33 inches, dark reddish-brown (2.5YR 3/4) silty clay, dark red (2.5YR 3/6) when dry; moderate, very fine, subangular blocky structure; hard, friable, sticky and plastic; abundant roots; many very fine and fine pores; nearly continuous pressure cutans; patchy, glazed coatings that appear to be sesquioxides; a few pebble-size pieces of saprolite; this horizon is capped by a thin, discontinuous ironstone seam 1 millimeter to 2 millimeters thick; a root mat has built up in places on this ironstone seam; strongly acid; clear, smooth boundary. 5 to 12 inches thick.

B23—33 to 43 inches, dark-red (2.5YR 3/6) silty clay, yellowish red (5YR 5/6) when dry; moderate, fine and medium, subangular blocky structure; hard, friable, sticky and plastic; abundant roots; many very fine and fine pores; pebble-size pieces of saprolite; pores filled with white material; patchy surfaces that look like pressure cutans; this horizon is capped by a very thin, discontinuous ironstone seam in which there is a buildup of roots; very strongly acid; gradual, wavy boundary. 0 to 10 inches thick.

B24—43 to 62 inches, variegated dark-red (2.5YR 3/6), yellowish-red (5YR 4/6), reddish-yellow (7.5YR 6/8), and very dusky red (2.5YR 2/2) silty clay; yellowish red (5YR 4/6) when dry; weak, medium and coarse, subangular blocky structure; hard, friable, sticky and plastic; few roots; many very fine and fine pores; few fragments of saprolite; few, thick, patchy cutans that look like clay flows; thin, platy material (probably gibbsite) gives some areas a platy appearance; very strongly acid.

The A horizon ranges from 7.5YR to 10YR in hue, from 3 to 4 in chroma, and from 3 to 4 in value. The B2 horizon ranges from 4 to 6 in chroma.

This soil is used for pasture, sugarcane, wildlife habitat, woodland, and water supply. (Capability classification IIIs, nonirrigated; sugarcane group 2; pasture group 10; woodland group 9)

Pooku silty clay, 8 to 15 percent slopes (PmC).—On this soil, runoff is slow to medium and the erosion hazard is slight to moderate.

This soil is used for pasture, sugarcane, wildlife habitat, woodland, and water supply. (Capability classification IIIe, nonirrigated; sugarcane group 2; pasture group 10; woodland group 9)

Pooku silty clay, 15 to 25 percent slopes (PmD).—On this soil, runoff is medium and the erosion hazard is moderate.

This soil is used for pasture, wildlife habitat, woodland, water supply, and sugarcane. (Capability classification IVe, nonirrigated; sugarcane group 2; pasture group 10; woodland group 9)

Pooku silty clay, 25 to 40 percent slopes (PmE).—This soil is similar to Pooku silty clay, 0 to 8 percent slopes, except that it is steep and the surface layer is thinner. Runoff is rapid, and the erosion hazard is severe. Included in mapping were small, eroded areas.

This soil is used for pasture, woodland, wildlife habitat, and water supply. (Capability classification VIe, nonirrigated; pasture group 10; woodland group 9)

Pooku silty clay loam, 3 to 8 percent slopes (PlB).—This soil is generally similar to Pooku silty clay, 0 to 8 percent slopes, except that the texture of the surface layer is silty clay loam and the soil has more ironstone sheets than is typical. Also, the lower part of the subsoil is yellower, has weaker structure, and has a texture of silty clay loam. Runoff is slow, and the erosion hazard is slight.

This soil is used for sugarcane, wildlife habitat, water supply, and woodland. (Capability classification IIIs, nonirrigated; sugarcane group 2; pasture group 10; woodland group 9)

Pooku silty clay loam, 8 to 25 percent slopes (PlD).—This soil is similar to Pooku silty clay, 0 to 8 percent slopes, except that the texture of the surface layer is silty clay loam and the soil has more ironstone sheets than is typical. Also, the lower part of the subsoil is yellower, has weaker structure, and has a texture of

silty clay loam. Runoff is slow to medium, and the erosion hazard is slight to moderate.

This soil is used for sugarcane, pasture, wildlife habitat, water supply, and woodland. (Capability classification IVe, nonirrigated; sugarcane group 2; pasture group 10; woodland group 9)

Puhi Series

This series consists of well-drained soils on uplands on the island of Kauai. These soils developed in material derived from basic igneous rock. They are nearly level to steep. Elevations range from 175 to 500 feet. The annual rainfall amounts to 60 to 80 inches. The mean annual soil temperature is 73° F. Puhi soils are geographically associated with Lihue and Kapaa soils.

These soils are used for sugarcane, pineapple, truck crops, orchards, pasture, woodland, wildlife habitat, water supply, and homesites. The natural vegetation consists of guava, Java plum, pangolagrass, kikuyugrass, elephantopus, joee, yellow foxtail, and rhodomyrtus.

Puhi silty clay loam, 0 to 3 percent slopes (PnA).—This soil is on broad interfluves on the uplands.

In a representative profile the surface layer is brown silty clay loam about 12 inches thick. The subsoil, about 48 inches thick, is reddish-brown and dark reddish-brown silty clay loam and silty clay that has subangular blocky structure. The substratum is silty clay. The surface layer is very strongly acid. The subsoil is slightly acid to medium acid.

Permeability is moderately rapid. Runoff is very slow, and there is no erosion hazard. The available water capacity is about 1.3 inches per foot of soil. In places, roots penetrate to a depth of 5 feet or more.

Representative profile: Island of Kauai, lat. 22°01′14″ N. and long. 159°23′8.1″ W.

Ap—0 to 12 inches, brown (10YR 4/3) silty clay loam, brown (10YR 4/3) when rubbed, yellowish brown (10YR 5/4) when dry; moderate, very fine, subangular blocky structure; hard, friable, slightly sticky and slightly plastic; abundant roots; many, very fine and fine, tubular pores and common interstitial pores; many gritty particles that are hard to break down; delayed effervescence with hydrogen peroxide; very strongly acid; abrupt, wavy boundary. 11 to 14 inches thick.

B21—12 to 21 inches, reddish-brown (5YR 4/4) silty clay loam, yellowish red (5YR 4/6) when dry; weak, very fine and fine, subangular blocky structure; hard, friable, slightly sticky and slightly plastic; plentiful fine and very fine roots; many very fine pores and common fine pores; nearly continuous, shiny glaze on peds; patchy coatings that look like clay films on some peds; medium acid; gradual, smooth boundary. 7 to 11 inches thick.

B22—21 to 33 inches, dark reddish-brown (5YR 3/4) silty clay loam, yellowish red (5YR 4/6) when dry; common black specks; moderate, very fine and fine, subangular blocky structure; hard, friable, slightly sticky and slightly plastic; plentiful fine and very fine roots; many very fine pores and common fine pores; nearly continuous, shiny glaze on peds; patchy coatings that look like clay films on some peds; stringy coatings of stronger chroma; slightly acid; gradual, smooth boundary. 10 to 14 inches thick.

B23—33 to 41 inches, dark reddish-brown (2.5YR 3/4) silty clay loam, yellowish red (5YR 4/6) when dry; moderate, very fine, subangular blocky structure; hard, friable, slightly sticky and plastic; few very fine roots; many very fine pores and common medium pores; continuous, shiny glaze on peds; patchy coatings that look like clay films on peds; many shiny particles; many, very fine, black specks; medium acid; gradual, smooth boundary. 6 to 9 inches thick.

B24—41 to 60 inches, dark reddish-brown (5YR 3/3) silty clay, yellowish red (5YR 4/8) when dry; strong, very fine and fine, subangular blocky structure; hard, firm, sticky and plastic; few very fine roots; many very fine and fine pores and common medium pores; continuous, shiny glaze on peds; many, very fine, black specks and shiny particles; medium acid.

The A horizon ranges from 7.5YR to 10YR in hue, from 2 to 4 in value, and from 2 to 4 in chroma. The B horizon ranges from 2.5YR to 7.5YR in hue, from 3 to 4 in value, and from 3 to 4 in chroma.

This soil is used for sugarcane, pineapple, orchards, truck crops, pasture, and homesites. (Capability classification IIs, irrigated or nonirrigated; sugarcane group 1; pineapple group 4; pasture group 8; woodland group 7)

Puhi silty clay loam, 3 to 8 percent slopes (PnB).—On this soil, runoff is slow and the erosion hazard is slight.

This soil is used for sugarcane, pineapple, orchards, pasture, truck crops, and homesites. (Capability classification IIe, irrigated or nonirrigated; sugarcane group 1; pineapple group 5; pasture group 8; woodland group 7)

Puhi silty clay loam, 8 to 15 percent slopes (PnC).—On this soil, runoff is slow and the erosion hazard is slight.

This soil is used for sugarcane, pineapple, pasture, and orchards. (Capability classification IIIe, irrigated or nonirrigated; sugarcane group 1; pineapple group 6; pasture group 8; woodland group 7)

Puhi silty clay loam, 15 to 25 percent slopes (PnD).—On this soil, runoff is medium and the erosion hazard is moderate. Included in mapping were small, eroded areas.

This soil is used for sugarcane, pineapple, orchards, pasture, woodland, wildlife habitat, and water supply. (Capability classification IVe, irrigated or nonirrigated; sugarcane group 1; pineapple group 6; pasture group 8; woodland group 7)

Puhi silty clay loam, 25 to 40 percent slopes (PnE).—On this soil, runoff is rapid and the erosion hazard is severe.

This soil is used for pasture, woodland, wildlife habitat, and water supply. (Capability classification VIe, nonirrigated; pasture group 8; woodland group 7)

Pulehu Series

This series consists of well-drained soils on alluvial fans and stream terraces and in basins. These soils occur on the islands of Lanai, Maui, Molokai, and Oahu. They developed in alluvium washed from basic igneous rock. The soils are nearly level to moderately sloping. Elevations range from nearly sea level to 300 feet. The annual rainfall amounts to 10 to 35 inches. The mean annual soil temperature is 74° F. Pulehu soils are geographically associated with Ewa, Jaucas, Kealia, Lualualei, Waialua, and Mala soils.

These soils are used for sugarcane, truck crops, pasture, homesites, and wildlife habitat. The natural vegetation consists of bermudagrass, bristly foxtail, fingergrass, kiawe, klu, lantana, koa haole, and sandbur.

Pulehu clay loam, 0 to 3 percent slopes (PsA).—This soil is on alluvial fans and stream terraces and in basins. Included in mapping were small areas of Ewa, Mala,

and Waialua soils. Also included were small areas of gravelly, stony, and gently sloping soils.

In a representative profile the surface layer is dark-brown clay loam about 21 inches thick. This is underlain by dark-brown, dark grayish-brown, and brown, massive and single grain, stratified loam, loamy sand, fine sandy loam, and silt loam about 39 inches thick. Below this is coarse, gravelly or sandy alluvium. The soil is neutral in the surface layer and neutral to mildly alkaline below the surface layer.

Permeability is moderate. Runoff is slow, and the erosion hazard is no more than slight. The available water capacity is about 1.4 inches per foot in the surface layer and subsoil. In places roots penetrate to a depth of 5 feet or more. Low areas are subject to flooding.

Representative profile: Island of Oahu, lat. 21°34′38″ N. and long. 158°09′51″ W.

Ap1—0 to 7 inches, very dark brown (10YR 2/2) clay loam, dark brown (10YR 3/3) when dry; weak, fine and medium, granular structure; hard, friable, sticky and plastic; abundant very fine and fine roots; common, fine and very fine, interstitial pores; few rounded pebbles; slight effervescence with hydrogen peroxide; neutral; gradual, smooth boundary. 5 to 8 inches thick.

Ap2—7 to 21 inches, very dark brown (10YR 2/2) clay loam, dark brown (10YR 3/3) when dry; weak, fine and medium, subangular blocky structure; hard, friable, sticky and plastic; abundant very fine and fine roots; common, fine and very fine, interstitial pores and common, fine, tubular pores; slight effervescence with hydrogen peroxide; neutral; abrupt, wavy boundary. 9 to 14 inches thick.

IIC1—21 to 33 inches, dark-brown (10YR 3/3) loam, dark brown (10YR 4/3) when dry; massive; slightly hard, very friable, slightly sticky and slightly plastic; plentiful fine roots; common, very fine and fine, tubular pores; neutral; abrupt, wavy boundary. 8 to 12 inches thick.

IIIC2—33 to 37 inches, very dark grayish-brown (10YR 3/2) loamy sand, dark grayish brown (10YR 4/2) when dry; single grain; loose when dry or moist, nonsticky and nonplastic; few fine roots; porous; mildly alkaline; abrupt, wavy boundary. 0 to 6 inches thick.

IVC3—37 to 47 inches, dark-brown (10YR 3/3) fine sandy loam, dark brown (10YR 4/3) when dry; massive; slightly hard, very friable, slightly sticky and slightly plastic; few fine roots; common, fine, tubular pores; mildly alkaline; abrupt, wavy boundary. 8 to 10 inches thick.

VC4—47 to 60 inches, dark-brown (10YR 3/3) silt loam, brown (10YR 5/3) when dry; massive; slightly hard, friable, sticky and plastic; few fine roots; common, fine, tubular pores; mildly alkaline.

The main variation is in the range in thickness and texture of the layers in the C horizon. The thickness of the layers ranges from less than 1 inch to more than 12 inches. The texture ranges from sand to silty clay loam. Throughout the profile, the soil ranges from 10YR to 7.5YR in hue, from 2 to 3 in value when moist and 3 to 5 when dry, and from 1 to 3 in chroma when moist or dry. Gravel is common on the surface and is scattered throughout the profile.

This soil is used for sugarcane, truck crops, and pasture. (Capability classification I if irrigated, IVc if nonirrigated; sugarcane group 1; pasture group 2)

Pulehu cobbly clay loam, 0 to 3 percent slopes (PtA).—This soil is similar to Pulehu clay loam, 0 to 3 percent slopes, except that it is cobbly.

This soil is used for sugarcane. Small acreages are used for pasture. (Capability classification IIs if irrigated, IVs if nonirrigated; sugarcane group 1; pasture group 2)

Pulehu cobbly clay loam, 3 to 7 percent slopes (PtB).—On this soil, runoff is slow and the erosion hazard is slight. Included in mapping were small areas that have thin, stratified layers of sand and gravel at a depth of 20 to 36 inches.

This soil is used for sugarcane. Small acreages are used for pasture. (Capability classification IIe if irrigated, IVs if nonirrigated; sugarcane group 1; pasture group 2)

Pulehu stony clay loam, 2 to 6 percent slopes (PuB).—On this soil, there are sufficient stones to hinder tillage but not enough to make intertilled crops impracticable. Runoff is slow, and the erosion hazard is slight.

This soil is used for sugarcane, truck crops, and pasture. Capability classification IIe if irrigated, IVs if nonirrigated; sugarcane group 1; pasture group 2)

Pulehu very stony clay loam, 0 to 12 percent slopes (PvC).—This soil is similar to Pulehu clay loam, 0 to 3 percent slopes, except that as much as 3 percent of the surface is covered with stones. Runoff is slow to medium, and the erosion hazard is slight to moderate. Workability is difficult because of the stones.

This soil is used for pasture and wildlife habitat. (Capability classification IVs, nonirrigated; sugarcane group 1; pasture group 2)

Pulehu silt loam, 0 to 3 percent slopes (PpA).—This soil is similar to Pulehu clay loam, 0 to 3 percent slopes, except that the texture is silt loam. This soil is used for sugarcane. Small acreages are used for homesites. (Capability classification I if irrigated, IVc if nonirrigated; sugarcane group 1; pasture group 2)

Pulehu silt loam, 3 to 7 percent slopes (PpB).—This soil is similar to Pulehu clay loam, 0 to 3 percent slopes, except that the texture is silt loam. Runoff is slow, and the erosion hazard is slight. Included in mapping were small areas underlain by coral sand at a depth of 20 to 36 inches.

This soil is used for sugarcane. (Capability classification IIe if irrigated, IVc if nonirrigated; sugarcane group 1; pasture group 2)

Pulehu cobbly silt loam, 0 to 3 percent slopes (PrA).—This soil is similar to Pulehu clay loam, 0 to 3 percent slopes, except that the texture is silt loam and there are many cobblestones on the surface. In a few places cobblestones are common throughout the profile. Included in mapping were small areas underlain by coral sand at a depth of 20 to 36 inches.

This soil is used for sugarcane and pasture. (Capability classification IIs if irrigated, IVs if nonirrigated; sugarcane group 1; pasture group 2)

Pulehu cobbly silt loam, 3 to 7 percent slopes (PrB).—This soil is similar to Pulehu clay loam, 0 to 3 percent slopes, except that the texture is silt loam, and the surface layer is cobbly. Runoff is slow, and the erosion hazard is slight. Included in mapping were small areas underlain by coral sand at a depth of 20 to 36 inches.

This soil is used for sugarcane. Small areas are used for pasture. (Capability classification IIe if irrigated, IVs if nonirrigated; sugarcane group 1; pasture group 2)

Pulehu sandy loam, 2 to 6 percent slopes (PoB).—This soil is similar to Pulehu clay loam, 0 to 3 percent slopes,

except that the texture is sandy loam. Runoff is slow, and the erosion hazard is slight.

This soil is used for pasture and wildlife habitat. (Capability classification IIIe if irrigated, VIs if nonirrigated; sugarcane group 1; pasture group 2)

Pulehu stony sandy loam, 0 to 7 percent slopes (PoaB).—This soil is similar to Pulehu clay loam, 0 to 3 percent slopes, except that the texture is sandy loam. There are sufficient stones to hinder tillage but not enough to make intertilled crops impractical.

This soil is used for pasture and wildlife habitat. (Capability classification IIIe if irrigated, VIs if nonirrigated; sugarcane group 1; pasture group 2)

Puuone Series

This series consists of somewhat excessively drained soils on low uplands on the island of Maui. These soils developed in material derived from coral and seashells. They are moderately sloping to moderately steep. Elevations range from 50 to 350 feet. The annual rainfall amounts to 20 to 30 inches, most of which occurs in winter. The mean annual soil temperature is 75° F. Puuone soils are geographically associated with Iao and Jaucas soils.

These soils are used for pasture and homesites. The natural vegetation consists of bermudagrass, kiawe, and lantana.

Puuone sand, 7 to 30 percent slopes (PZUE).—This soil is on sandhills near the ocean. Included in mapping were small areas of Iao and Jaucas soils. Also included were small areas where the cemented layer is less than 20 inches below the surface.

In a representative profile the surface layer is grayish-brown, calcareous sand about 20 inches thick. This is underlain by grayish-brown, cemented sand. The soil is moderately alkaline in the surface layer.

Permeability is rapid above the cemented layer. Runoff is slow, and the hazard of wind erosion is moderate to severe. The available water capacity is about 0.7 inches per foot in the surface layer and subsoil. In places roots penetrate to the cemented layer.

Representative profile: Island of Maui, lat. 20°54′40″ N. and long. 156°29′30″ W.

C1—0 to 20 inches, grayish-brown (10YR 5/2) sand, light brownish gray (10YR 6/2) when dry; single grain; loose, nonsticky and nonplastic; abundant fine roots; porous; violent effervescence with hydrochloric acid; moderately alkaline; abrupt, wavy boundary. 20 to 40 inches thick.

C2cam—20 to 40 inches, grayish-brown (10YR 5/2), strongly cemented sand, light brownish gray (10YR 6/2) when dry; massive; very hard, very firm, nonsticky and nonplastic; few fine roots in cracks; breaks down under treatment with dilute hydrochloric acid, but not with water; violent effervescence with hydrochloric acid; strongly alkaline.

The depth to the lime hardpan ranges from 20 to 40 inches. It is common to find old root channels filled with a hard, white material that effervesces violently with hydrochloric acid.

The soil is used for pasture and homesites. (Capability classification VIIe, nonirrigated; pasture group 1)

Puu Opae Series

This series consists of well-drained soils on uplands on the island of Kauai. These soils developed in material weathered from basic igneous rock. They are moderately sloping to steep. Elevations range from 500 to 2,500 feet. The annual rainfall amounts to 30 to 50 inches. The mean annual soil temperature is 70° F. Puu Opae soils are geographically associated with Mahana soils.

These soils are used for pasture, woodland, and wildlife habitat. A small acreage is in sugarcane. The natural vegetation consists of molassesgrass, silver oak, passion flower, puakeawe, yellow foxtail, lantana, uluhe, ti, and aalii.

Puu Opae silty clay loam, 8 to 15 percent slopes (PwC).—This soil is on the tops of ridges in the uplands.

In a representative profile the surface layer, about 10 inches thick, is dusky-red silty clay loam that has subangular blocky structure. The subsoil, more than 41 inches thick, is reddish-brown and dark reddish-brown silty clay that has subangular blocky structure. The substratum is soft, weathered rock. The surface layer is medium acid to strongly acid. The subsoil is strongly acid to very strongly acid.

Permeability is moderately rapid. Runoff is slow to medium, and the erosion hazard is slight to moderate. The available water capacity is about 1.4 inches per foot of soil. In places roots penetrate to a depth of 5 feet or more.

Representative profile: Island of Kauai, lat. 22°02′16.6″ N. and long. 159°41′52″ W.

A11—0 to 7 inches, dusky-red (2.5YR 3/2) silty clay loam, weak red (2.5YR 4/2) when dry; moderate, fine and very fine, subangular blocky structure; slightly hard, friable, sticky and plastic; abundant roots; many fine pores; strong effervescence with hydrogen peroxide; strongly acid; clear, smooth boundary. 6 to 8 inches thick.

A12—7 to 10 inches, dusky-red (2.5YR 3/2) loam, dark reddish brown (2.5YR 3/3) when dry; weak, fine, subangular blocky structure; weakly coherent, very friable, slightly sticky and slightly plastic; abundant roots; many fine pores; strong effervescence with hydrogen peroxide; medium acid; clear, smooth boundary. 3 to 5 inches thick.

B1—10 to 14 inches, dark reddish-brown (2.5YR 3/3) light silty clay, reddish brown (2.5YR 4/3) when dry; moderate, fine and very fine, subangular blocky structure; hard, friable, sticky and plastic; abundant roots; many fine pores; very few, thin clay films on ped faces; moderate effervescence with hydrogen peroxide; strongly acid; clear, smooth boundary. 3 to 5 inches thick.

B21t—14 to 29 inches, reddish-brown (2.5YR 4/4) silty clay, reddish brown (2.5YR 4/4) when dry; weak, fine and very fine, subangular blocky structure; hard, firm, very sticky and plastic; plentiful roots; common fine and very fine pores; thin, patchy clay films on ped faces; no effervescence with hydrogen peroxide; strongly acid; gradual, smooth boundary. 12 to 18 inches thick.

B22t—29 to 61 inches, reddish-brown (2.5YR 4/3) silty clay, reddish brown (2.5YR 4/3) when dry; moderate, fine and very fine, angular blocky structure; hard, firm, very sticky and plastic; few roots; few fine and very fine pores; nearly continuous, moderately thick clay films on ped faces; sugarlike coatings of higher chroma in pores; strongly acid; gradual, smooth boundary. 26 to 38 inches thick.

B23t—61 inches, dark reddish-brown (2.5YR 3/4) silty clay, weak red (2.5YR 4/2) when dry; strong, fine and very fine, angular and subangular blocky structure; hard, firm, sticky and plastic; very few roots; few fine pores; glazed appearance; continuous, moderately thick clay films on ped faces; sugarlike coatings of higher chroma in pores; very strongly acid.

The profile ranges from 10R to 2.5YR in hue. The B horizon ranges from 3 to 4 in chroma and from 2 to 6 in value.

This soil is used for pasture, woodland, and wildlife habitat. A small acreage is in irrigated sugarcane. (Capability classification IIIe, irrigated or nonirrigated; pasture group 6; woodland group 5)

Puu Opae silty clay loam, 15 to 25 percent slopes (PwD).—On this soil, runoff is medium and the erosion hazard is moderate.

This soil is used for pasture, woodland, wildlife habitat, and water supply. (Capability classification IVe, irrigated or nonirrigated; pasture group 6; woodland group 5)

Puu Opae silty clay loam, 25 to 40 percent slopes (PwE).—This soil is similar to Puu Opae silty clay loam, 8 to 15 percent slopes, except that the A horizon is thinner. Runoff is rapid, and the erosion hazard is severe.

This soil is used for pasture, woodland, wildlife habitat, and water supply. (Capability classification VIe, nonirrigated; pasture group 6; woodland group 5)

Puu Pa Series

This series consists of well-drained soils on uplands on the island of Maui. These soils developed in volcanic ash overlying fragmental Aa lava. They are moderately sloping to steep. Elevations range from 1,000 to 2,200 feet. The annual rainfall amounts to 20 to 35 inches. The mean annual soil temperature is 70° F. Puu Pa soils are geographically associated with Uma and Waiakoa soils.

These soils are used for pasture and wildlife habitat. The natural vegetation consists of bermudagrass, indigo, lantana, and Natal redtop.

Puu Pa very stony silt loam, 7 to 40 percent slopes (PZVE).—This soil is on the southern intermediate slopes of Haleakala. The landscape is dissected by many small gulches. Included in mapping were small areas of Uma and Waiakoa soils. Also included were small, very steep areas.

In a representative profile the surface layer, about 10 inches thick, is very dark brown silt loam that has subangular blocky structure. The next layer, about 37 inches thick, is very dark brown and very dark grayish-brown silt loam that is massive. Below this is fragmental Aa lava. The soil is medium acid to slightly acid in the surface layer and neutral below the surface layer.

Permeability is moderately rapid. Runoff is slow to medium, and the erosion hazard is slight to moderate. The available water capacity is about 1.7 inches per foot in the surface layer and subsoil. In places roots penetrate to a depth of 3 feet or more.

Representative profile: Island of Maui, lat. 20°39′15″ N. and long. 156°12′52″ W.

A11—0 to 5 inches, very dark brown (10YR 2/2) very stony silt loam, dark brown (10YR 3/3) when dry; weak, fine and medium, subangular blocky structure; slightly hard, very friable, slightly sticky and nonplastic; abundant fine roots; many fine and very fine pores; common, very fine, gritty particles that break down slowly under continued rubbing; on top of this horizon is an intermittent ash deposit as much as ¼ inch thick; very weak effervescence with hydrogen peroxide; medium acid; abrupt, wavy boundary. 3 to 6 inches thick.

A12—5 to 10 inches, very dark brown (10YR 2/2) gravelly and cobbly silt loam, dark brown (10YR 3/3) when dry; weak, medium, subangular blocky structure; slightly hard, very friable, slightly sticky and nonplastic; abundant fine roots; many fine and very fine pores; 30 to 40 percent gravel and cobblestones; slightly acid; clear, wavy boundary. 4 to 6 inches thick.

AC—10 to 15 inches, very dark brown (10YR 2/2) gravelly and cobbly silt loam, dark brown (10YR 4/3) when dry; massive; slightly hard, very friable, slightly sticky and nonplastic; abundant fine roots; many fine pores; few, fine, hard, earthy lumps; 30 to 40 percent gravel and cobblestones; a few pebbles and cobblestones are slightly weathered; neutral; clear, wavy boundary. 4 to 6 inches thick.

C1—15 to 19 inches, very dark grayish-brown (10YR 3/2) gravelly and cobbly silt loam, dark yellowish brown (10YR 4/4) when dry; massive; slightly hard, very friable, slightly sticky and nonplastic; plentiful fine roots; common fine pores; common, hard, earthy lumps; 40 to 50 percent gravel and cobblestones; a few highly weathered rock fragments; neutral; clear, wavy boundary. 3 to 6 inches thick.

C2—19 to 31 inches, very dark grayish-brown (10YR 3/2) very gravelly and cobbly silt loam, dark yellowish brown (10YR 4/4) when dry; massive; slightly hard, very friable, slightly sticky and nonplastic; plentiful fine roots; many fine pores; few, hard, earthy lumps; 60 to 70 percent gravel and cobblestones; few highly weathered rock fragments; neutral; gradual, wavy boundary. 10 to 15 inches thick.

C3—31 to 47 inches, dark-brown (10YR 3/3) very gravelly and cobbly silt loam, brown (10YR 4/3) when dry; massive; soft, very friable, slightly sticky and nonplastic; many fine pores; 70 to 80 percent gravel and cobblestones; common weathered gravel and cobblestones; neutral.

IIC4—47 inches, Aa lava and very little soil material.

The depth to Aa lava ranges from 20 to 50 inches. The A horizon ranges from 7.5YR to 10YR in hue, from 2 to 3 in value when moist, and from 2 to 3 in chroma when moist or dry. The texture is loam or silt loam. The C horizon ranges from 2 to 3 in value when moist and 3 to 4 when dry, and from 2 to 3 in chroma when moist.

This soil is used for pasture and wildlife habitat. (Capability classification VIs, nonirrigated; pasture group 2)

Riverwash

Riverwash (rRH) consists of nearly level bars of sand, gravel, and stones along perennial and intermittent streams on the island of Kauai. In places it consists mainly of large stones and boulders. It is nearly bare of vegetation and is subject to overflow and shifting during normally high water.

Accessible areas of Riverwash are sources of material for roadbuilding and other kinds of construction. This land type, however, is used mainly for wildlife habitat. (Capability classification VIIIw, nonirrigated)

Rock Land

Rock land (rRK) is made up of areas where exposed rock covers 25 to 90 percent of the surface. It occurs on all five islands. The rock outcrops and very shallow soils are the main characteristics. The rock outcrops are mainly basalt and andesite. This land type is nearly level to very steep. Elevations range from nearly sea level to more than 6,000 feet. The annual rainfall amounts to 15 to 60 inches.

Rock land is used for pasture, wildlife habitat, and water supply. The natural vegetation at the lower elevations consists mainly of kiawe, klu, piligrass, Japanese tea, and koa haole. Lantana, guava, Natal redtop, and molassesgrass are dominant at the higher elevations. This land type is also used for urban development. In many areas, especially on the island of Oahu, the soil material associated with the rock outcrops is very sticky and very plastic. It also has high shrink-swell potential. Buildings on the steep slopes are susceptible to sliding when the soil is saturated. Foundations and retaining walls are susceptible to cracking. (Capability classification VIIs, nonirrigated)

Rock Outcrop

Rock outcrop (rRO) consists of areas where exposed bedrock covers more than 90 percent of the surface. It occurs on all five islands. The rock outcrops are mainly basalt and andesite. This land type is gently sloping to precipitous. Elevations range from nearly sea level to 10,000 feet. Included in mapping were a small area of lithified coral sand on Molokai and small areas of coral outcrop along the coasts of other islands.

This land type is not suited to farming. It is used for water supply, wildlife habitat, and recreation. (Capability classification VIIIs, nonirrigated)

Rough Broken Land

Rough broken land (rRR) consists of very steep land broken by numerous intermittent drainage channels. In most places it is not stony. It occurs in gulches and on mountainsides on all the islands except Oahu. The slope is 40 to 70 percent. Elevations range from nearly sea level to about 8,000 feet. The local relief is generally between 25 and 500 feet. Runoff is rapid, and geologic erosion is active. The annual rainfall amounts to 25 to more than 200 inches.

These soils are variable. They are 20 to more than 60 inches deep over soft, weathered rock. In most places some weathered rock fragments are mixed with the soil material. Small areas of rock outcrop, stones, and soil slips are common. Included in mapping were areas of colluvium and alluvium along gulch bottoms.

This land type is used primarily for watershed and wildlife habitat. In places it is used also for pasture and woodland. The dominant natural vegetation in the drier areas consists of guava, lantana, Natal redtop, bermudagrass, koa haole, and molassesgrass. Ohia, kukui, koa, and ferns are dominant in the wetter areas. Puakeawe, aalii, and sweet vernalgrass are common at the higher elevations. (Capability classification VIIe, nonirrigated)

Rough Broken and Stony Land

Rough broken and stony land (rRS) consists of very steep, stony gulches. The local relief is generally between 25 and 500 feet. Runoff is rapid, and geologic erosion is active. Elevations range from nearly sea level to 3,000 feet. The annual rainfall amounts to 20 to 40 inches.

The soil material is generally less than 20 inches deep over saprolite or bedrock. About 3 to 25 percent of the surface is covered with stones, and there are a few rock outcrops. Included in mapping were small areas of colluvium and alluvium along the bottoms of gulches.

This land type is used for pasture, wildlife habitat, and watershed. The dominant natural vegetation consists of lantana, koa, haole, klu, feather fingergrass, bermudagrass, and ilima. (Capability classification VIIs, nonirrigated)

Rough Mountainous Land

Rough mountainous land (rRT) occurs in mountainous areas on all islands in the survey area. Is consists of very steep land broken by numerous intermittent drainage channels. In most places it is not stony. Elevations range from nearly sea level to more than 6,000 feet. The annual rainfall amounts to 70 to more than 400 inches. Over much of the area, the soil mantle is very thin. It ranges from 1 inch to 10 inches in thickness over saprolite. In most places the saprolite is relatively soft and permeable to roots and water.

The land surface is dominated by deep, V-shaped valleys that have extremely steep side slopes and narrow ridges between the valleys. In most places the local relief exceeds 500 feet. The soil material on the narrow ridgetops is similar to that of the Amalu and Olokui series. Rock land, rock outcrop, soil slips, and eroded spots make up 20 to 40 percent of the acreage.

This land type is used for water supply, wildlife habitat, and recreation. The natural vegetation consists of ohia, false staghornfern, treefern, yellow foxtail, lantana, kukui, and puakeawe. (Capability classification VIIIe, nonirrigated)

Rubble Land

Rubble land (rRU) consists of areas where 90 percent of the surface is covered by stones or boulders. It occurs at the base of very steep to precipitous slopes in the western and southern parts of the island of Kauai. Elevations range from sea level to about 500 feet. The annual rainfall amounts to 22 to 50 inches.

This land type is used for wildlife habitat. The natural vegetation is mainly koa haole. (Capability classification VIIIs, nonirrigated)

Sandy Alluvial Land

Sandy alluvial land (rSL) occurs along the narrow coastal flats in the northern and northeastern parts of Lanai. It consists of recent stream deposits that vary widely in texture. Most areas are sandy and have few pebbles and stones. This land type is subject to flooding during the rainy season. In most places the slope is 0 to 5 percent, but in places it is as much as 15 percent. In areas exposed

to strong trade winds, the sand has been blown to form a hummocky topography. Elevations range from sea level to 25 feet. The annual rainfall amounts to about 10 inches.

This land type is used for wildlife habitat. The natural vegetation consists of kiawe, bristly foxtail, and fingergrass. Some areas are bare. (Capability classification VIIw, nonirrigated)

Stony Alluvial Land

Stony alluvial land (rSM) consists of stones, boulders, and soil deposited by streams along the bottoms of gulches and on alluvial fans. In most places the slope is 3 to 15 percent. Elevations range from nearly sea level to 1,000 feet. The annual rainfall amounts to 15 to 200 inches.

This land type is suited to pasture in the dry areas and to pasture and woodland in the wet areas. The natural vegetation consists of kiawe, klu, ilima, piligrass, and lantana in the dry areas and guava, kukui, hilograss, and Christmas berry in the wet areas. Improvement of this land is difficult because of the stones and boulders. (Capability classification VIIs, nonirrigated)

Stony Blown-out Land

Stony blown-out land (rSN) occurs on knolls and gulches, mainly in the northern part of Lanai. In most places the slope is 7 to 30 percent, but gulch sides as steep as 70 percent are included. Elevations range from 1,000 to 2,000 feet. The annual rainfall amounts to 15 to 25 inches.

On this land type (fig. 8), stones, boulders, and rock outcrop are common as a result of severe erosion by wind and water. The stones and boulders overlie soft, weathered rock. Included in mapping were small areas of windblown and alluvial material similar to that of Koele soils.

This land type produces a small amount of forage that is used by deer and antelope. The natural vegetation is sparse, but there is some molassesgrass, dallisgrass, lantana, and Natal redtop. (Capability classification VIIs, nonirrigated)

Stony Colluvial Land

Stony colluvial land (rSO) occurs on talus slopes at the base of the Kalaupapa cliffs on the island of Molokai. It consists of a mixture of stones and boulders and a small amount of soil material. The slope ranges from 25 to 40 percent. Elevations range from nearly sea level to 400 feet. The annual rainfall amounts to 30 to 60 inches.

Most of this land type is idle. The very stony condition and steep slopes make pasture improvement very difficult. The natural vegetation consists of Christmas berry, koa haole, kukui, false mallow, and Java plum. (Capability classification VIIs, nonirrigated)

Stony Land

Stony land (rST) occurs in valleys and on side slopes of drainageways on the island of Oahu. It is mainly between Barbers Point and Kaena Point. It consists of a mass of boulders and stones deposited by water and gravity. The slope ranges from 5 to 40 percent. Elevations range from nearly sea level to 500 feet. The annual rainfall amounts to 18 to 60 inches. Stony land is geographically associated with Lualualei and Ewa soils.

Stones and boulders cover 15 to 90 percent of the surface. The soil among the stones consists of reddish

Figure 8.—Typical landscape of Stony blown-out land.

silty clay loam that is similar to Ewa soils and very dark grayish-brown clay that is similar to Lualualei soils. In most places there is enough soil among the stones to provide a foothold for plants.

This land type is used for wildlife habitat and recreation. The natural vegetation consists of kiawe, lantana, koa haole, bermudagrass, and annuals. (Capability classification VIIs, nonirrigated)

Stony Steep Land

Stony steep land (rSY) consists of a mass of boulders and stones deposited by water and gravity on side slopes of drainageways. It occurs on the island of Oahu. The slope ranges from 40 to 70 percent. Elevations range from 100 to 1,500 feet. The annual rainfall amounts to 20 to 80 inches.

Stones and boulders cover 50 to 90 percent of the surface. There is a small amount of soil among the stones that provides a foothold for plants. Rock outcrops occur in many places.

This land type is used for wildlife habitat and recreation. The natural vegetation consists of kiawe, koa haole, and grasses. (Capability classification VIIs, nonirrigated)

Tantalus Series

This series consists of well-drained soils on uplands on the island of Oahu. These soils developed in volcanic ash and material weathered from cinders. They are moderately sloping to very steep. Elevations range from 100 to 2,200 feet. The annual rainfall amounts to 50 to 150 inches. It is well distributed throughout the year. The mean annual soil temperature is 70° F. Tantalus soils are geographically associated with Makiki soils.

These soils are used for homesites, water supply, and recreation. The natural vegetation consists of ferns, Formosa koa, koa haole, kukui, and eucalyptus.

Tantalus silt loam, 40 to 70 percent slopes (TAF).—This soil is on volcanic spurs and cinder cones in the uplands.

Included in mapping were small areas of Makiki soils. Also included were small cinder deposits and stony soils within the drainageways.

In a representative profile the surface layer, about 18 inches thick, is very dark brown silt loam that has subangular blocky structure. The subsoil, about 11 inches thick, is dark reddish-brown, massive very fine sandy loam. The substratum is black, unweathered, gravel-size cinders. The soil is neutral in the surface layer and subsoil.

Permeability is moderately rapid. Runoff is medium to rapid, and the erosion hazard is severe. In places roots penetrate to a depth of 3 feet.

Representative profile: Island of Oahu, lat. 21°19′48″ N. and long. 157°49′38″ W.

A1—0 to 18 inches, very dark brown (10YR 2/2) silt loam, dark brown (10YR 3/3) when dry; moderate, very fine and fine, subangular blocky structure; hard, friable, slightly sticky and slightly plastic; abundant very fine and fine roots; common, very fine, interstitial pores; common, fine and very fine, sharp cinders; neutral; clear, wavy boundary. 10 to 18 inches thick.

B2—18 to 29 inches, dark reddish-brown (5YR 3/4) very fine sandy loam, reddish brown (5YR 4/4) when dry; massive; soft, very friable, slightly sticky and slightly plastic, and weakly smeary; abundant very fine and fine roots and few medium and coarse roots; many, very fine and fine, tubular pores; abundant, very fine, sharp cinders; neutral; clear, wavy boundary. 6 to 12 inches thick.

IIC—29 inches, black, unweathered, fine, gravel-size cinders.

The solum ranges from 16 to 30 inches in thickness. The A horizon ranges from silt loam to silty clay loam in texture. It ranges from 5YR to 10YR in hue and from 2 to 3 in value and chroma. The texture of the B horizon is very fine sandy loam, silt loam, or silty clay loam. The B horizon ranges from 5YR to 10YR in hue and from 2 to 4 in chroma.

This soil is used for water supply and recreation. (Capability classification VIIe, nonirrigated; pasture group 9; woodland group 8)

Tantalus silt loam, 15 to 40 percent slopes (TAE).—On this soil, runoff is medium and the erosion hazard is moderate.

This soil is used for water supply and recreation. (Capability classification VIe, nonirrigated; pasture group 9; woodland group 8)

Tantalus silty clay loam, 8 to 15 percent slopes (TCC).—On this soil, runoff is slow and the erosion hazard is slight. Included in mapping were small areas of stony soils in the drainageways.

This soil is used for homesites, water supply, and recreation. (Capability classification IIIe, nonirrigated; pasture group 9; woodland group 8)

Tantalus silty clay loam, 15 to 40 percent slopes (TCE).—On this soil, runoff is medium and the erosion hazard is moderate.

This soil is used for homesites, water supply, and recreation. (Capability classification VIe, nonirrigated; pasture group 9; woodland group 8)

Tropaquepts

Tropaquepts (TR) are poorly drained soils that are periodically flooded by irrigation in order to grow crops that thrive in water. They occur as nearly level flood plains on the islands of Oahu and Maui. Elevations range from sea level to 200 feet. The annual rainfall amounts to 20 to 150 inches.

These soils have been flooded for varying lengths of time, and soil development differs in degree from place to place. Generally, the surface layer, about 10 inches thick, consists of dark-gray, soft, mucky silt loam. This layer overlies firm to compact silty clay loam, 5 to 10 inches thick, that is mottled with gray, yellow, and brown. The mottled layer overlies friable alluvium.

Tropaquepts are used for production of taro, rice, and watercress on flooded paddies. (Capability classification IVw, irrigated or nonirrigated)

Tropaquods

Areas mapped as Tropaquods (rTO) consist of steep-walled gulches and mountainsides on uplands on the island of Molokai. There are many intermittent streams in these areas. The slope ranges from 30 to 70 percent. Elevations range from 1,800 to 5,000 feet. Rainfall amounts to 80 to 150 inches or more annually. Fog and

clouds cover the areas most of the time. The slope and dense vegetation make most areas inaccessible.

The soil material resembles that of Amalu and Olokui soils. It is generally shallow over soft weathered rock, but in places it ranges from shallow to deep. In the less sloping areas, thin sheets of ironstone are common at a depth of 10 to 20 inches.

These areas serve as watersheds, and they provide habitat for wildlife. The vegetation consists of ohia, treefern, false staghornfern, sedges, and various kinds of rain forest vegetation. (Capability classification VIIw, nonirrigated)

Tropohumults-Dystrandepts Association

Areas mapped as Tropohumults-Dystrandepts association (rTP) consist of mountainous areas in the Waianae Range on the island of Oahu. The areas are dominated by deep, V-shaped drainageways and narrow ridges. The slope ranges from 30 to 90 percent. Elevations range from 1,000 to 4,000 feet. Rainfall amounts to 30 to 75 inches annually.

The soils in this association consist mainly of Tropohumults and Dystrandepts. Histosols make up a smaller part of the association. Areas of Rock land and Rock outcrop occur in the drainageways.

Tropohumults occur on narrow ridgetops at the higher elevations. These are well-drained, strongly acid to extremely acid soils that are similar to those of the Halawa series. The surface layer consists of reddish-brown silty clay that has strong structure and high bulk density. The subsoil has strong subangular blocky structure; it is underlain by an ironstone pan or by saprolite. A hard crust that has a purplish cast forms on these soils in some places where the vegetation has been depleted.

Dystrandepts are dark-colored, friable soils on steep side slopes and narrow ridgetops at the lower elevations. In most places the surface layer is silty clay. The subsoil is generally massive, but areas were included where the subsoil is fine textured. These soils formed mainly in volcanic ash, but partly in colluvium. They are well drained and medium to strongly acid. Except for color, they are similar to the reddish soils of the Mahana series.

Histosols occupy small, wet positions near mountain peaks. They are poorly drained and have accumulations of organic material as much as 3 feet thick. These soils are similar to those of the Alakai series.

Most of this association is very steep and inaccessible. It serves mainly as a watershed. At the lower elevations the natural vegetation consists of lantana, molassesgrass, and yellow foxtail. At the higher elevations the vegetation is mainly ohia, puakeawe, koa, aalii, and ferns. (Capability classification VIIe, nonirrigated)

Ulupalakua Series

This series consists of well-drained soils on intermediate mountain slopes on the island of Maui. These soils developed in volcanic ash and material weathered from cinders. They are moderately sloping to moderately steep. Elevations range from 2,400 to 4,500 feet. The annual rainfall amounts to 30 to 40 inches. Afternoon cloud cover and fog are common. The mean annual soil temperature is 65° F. Ulupalakua soils are geographically associated with Io and Kaipoioi soils.

These soils are used for pasture and wildlife habitat. The natural vegetation consists of brackenfern, dallisgrass, plantain, rattailgrass, Spanish clover, and white clover.

Ulupalakua silt loam, 7 to 25 percent slopes (ULD).—This soil is on smooth intermediate mountain slopes. Included in mapping were small areas of Io and Kaipoioi soils. Also included were small, very steep areas.

In a representative profile the surface layer is very dark brown silt loam about 9 inches thick. The subsoil, about 24 inches thick, is dark reddish-brown silt loam and clay loam that has subangular blocky structure. The substratum is black, unweathered cinders. The soil is slightly acid in the surface layer and neutral to mildly alkaline in the subsoil.

Permeability is moderately rapid. Runoff is slow, and the erosion hazard is slight. In places roots penetrate to a depth of 3 feet or more.

Representative profile: Island of Maui, lat. 20°48′28″ N. and long. 156°22′58″ W.

Ap—0 to 9 inches, very dark brown (10YR 2/2) silt loam, dark grayish brown (10YR 4/2) when dry; strong, medium and fine, granular structure; slightly hard, very friable, slightly sticky and nonplastic; abundant fine roots; many fine and medium pores; 15 to 20 percent very fine cinders, which causes a gritty feel; slightly acid; clear, wavy boundary. 8 to 11 inches thick.

B21—9 to 19 inches, dark reddish-brown (5YR 2/2) silt loam, dark reddish brown (5YR 3/3) when dry; strong, fine and very fine, subangular blocky structure; slightly hard, very friable, slightly sticky and nonplastic; abundant fine roots; many fine and very fine pores; patchy, gelatinlike coatings on peds; few, fine, black cinders; common sand-size aggregates that are resistant to crushing; neutral; clear, wavy boundary. 8 to 12 inches thick.

B22—19 to 28 inches, dark reddish-brown (5YR 2/2) silt loam, dark brown (7.5YR 3/2) when dry; strong, very fine, subangular blocky structure; slightly hard, very friable, slightly sticky and nonplastic; plentiful fine roots; many fine pores; patchy, gelatinlike coatings on peds; few pockets of slightly weathered cinders; mildly alkaline; clear, smooth boundary. 8 to 11 inches thick.

B23—28 to 33 inches, dark reddish-brown (5YR 2/2) clay loam, dark reddish brown (5YR 3/2) when dry; strong, medium and fine, subangular blocky structure; slightly hard, friable, sticky and slightly plastic; plentiful fine roots; many fine pores; patchy, gelatinlike coatings on peds; mildly alkaline; abrupt, wavy boundary. 4 to 6 inches thick.

IIC—33 inches, black, unweathered cinders and a few yellowish-red, weathered cinders; slight effervescence with hydrochloric acid.

The solum is 28 to 40 inches thick over black, unweathered cinders. At the higher elevations, the soil is weakly smeary. The B horizon ranges from 5YR to 7.5YR in hue. The texture ranges from silt loam to clay loam. Gelatinous coatings on peds are more numerous where rainfall is higher.

This soil is used for pasture and wildlife habitat. (Capability classification IVe, nonirrigated; pasture group 5; woodland group 3)

Uma Series

This series consists of excessively drained, sandy soils on intermediate mountain slopes on the island of Maui.

These soils developed in volcanic ash and material weathered from cinders. They are on moderately sloping to very steep intermediate mountain slopes. Elevations range from 2,500 to 6,000 feet. The annual rainfall amounts to 30 to 40 inches. Afternoon fog and cloud cover are common. The mean annual soil temperature is 56° F. Uma soils are geographically associated with Puu Pa and Ulupalakua soils.

These soils are used for pasture and wildlife habitat. The natural vegetation consists of kikuyugrass, rattailgrass, and sweet vernalgrass.

Uma loamy coarse sand, 15 to 40 percent slopes (UME).—This soil is on smooth, intermediate mountain slopes. Included in mapping were small areas of Puu Pa and Ulupalakua soils. Also included were a few cinder cones and small areas of rock outcrop.

In a representative profile the surface layer, about 6 inches thick, is black loamy coarse sand that has granular structure. The substratum is black, unweathered cinders, 3 to 10 millimeters in size. The soil is mildly alkaline in the surface layer.

Permeability is very rapid. Runoff is slow, and the erosion hazard is slight to moderate. In places, roots penetrate to a depth of about 1 foot.

Representative profile: Island of Maui, lat. 20°39′00″ N. and long. 156°24′50″ W.

A1—0 to 6 inches, black (5YR 2/1) loamy coarse sand, dark brown (7.5YR 3/2) when dry; weak, very fine, granular structure; soft, very friable, nonsticky and nonplastic; abundant fine and very fine roots; many, very fine, interstitial pores; 5 to 10 percent cinders, 3 to 10 millimeters in size; mildly alkaline; abrupt, smooth boundary. 4 to 10 inches thick.

IIC—6 to 55 inches, black, unweathered cinders, 3 to 10 millimeters in size; single grain; loose; few roots.

The depth to cinders ranges from 4 to 10 inches. Intermittent layers of volcanic ash occur in the substratum near cinder cones. The A horizon ranges from 5YR to 10YR in hue and from 1 to 2 in chroma when moist.

This soil is used for pasture and wildlife habitat. (Capability classification VIs, nonirrigated; pasture group 4; woodland group 11)

Uma loamy coarse sand, 40 to 70 percent slopes (UMF).—This soil is similar to Uma loamy coarse sand, 15 to 40 percent slopes, except for the slope. The erosion hazard is severe. Included in mapping were small areas of rock outcrop and cinder cones.

This soil is used for pasture and wildlife habitat. (Capability classification VIIs, nonirrigated; pasture group 4; woodland group 11)

Uma rocky loamy coarse sand, 7 to 25 percent slopes (URD).—This soil is similar to Uma loamy coarse sand, 15 to 40 percent slopes, except that rock outcrops cover 5 to 10 percent of the surface. Runoff is medium, and the erosion hazard is moderate. Included in mapping were small areas where there are few to many stones on the surface and in the profile.

This soil is used for pasture and wildlife habitat. (Capability classification VIs, nonirrigated; pasture group 4; woodland group 11)

Uwala Series

This series consists of well-drained soils on uplands on the island of Lanai. These soils formed in material derived from basalt. They are gently sloping to moderately sloping. Elevations range from 500 to 1,500 feet. The annual rainfall amounts to 15 to 25 inches, most of which occurs between November and April. There is little rain in summer. The mean annual soil temperature is 70° F. Uwala soils are geographically associated with Molokai soils, along the southern edge of the central plateau.

These soils are used for pineapple and wildlife habitat. The natural vegetation consists of klu, lantana, feather fingergrass, uhaloa, ilima, and piligrass.

Uwala silty clay loam, 2 to 7 percent slopes (UwB).—This soil has smooth slopes. Included in mapping were small, severely eroded areas.

In a representative profile the surface layer is dark reddish-brown silty clay loam about 18 inches thick. The subsoil, about 39 inches thick, is dark reddish-brown silty clay loam that has subangular and angular blocky structure. Below this is very dark grayish-brown silty clay loam and soft, weathered rock. The soil is very strongly acid in the surface layer and medium acid in the subsoil.

Permeability is moderate. Runoff is slow to medium, and the erosion hazard is slight to moderate. The available water capacity is about 1.3 inches per foot of soil. In places roots penetrate to a depth of 5 feet or more.

Representative profile: Island of Lanai, lat. 20°46′26″ N. and long. 156°58′02″ W.

Ap1—0 to 5 inches, dark reddish-brown (5YR 3/3) silty clay loam, reddish brown (5YR 4/3) when dry; weak, medium and fine, subangular blocky structure breaking to weak, fine, granular; slightly hard, friable, slightly sticky and slightly plastic; many very fine roots; few, fine, interstitial pores; common, fine, black concretions; strong effervescence with hydrogen peroxide; very strongly acid; clear, wavy boundary. 3 to 6 inches thick.

Ap2—5 to 18 inches, dark reddish-brown (5YR 3/3) silty clay loam, reddish brown (5YR 4/3) when dry; weak, fine and medium, subangular blocky structure breaking to moderate, fine, granular; slightly hard, friable, slightly sticky and plastic; many very fine and fine roots; common, very fine, tubular and interstitial pores; few, fine, black concretions; common fragments of organic matter; moderate effervescence with hydrogen peroxide; very strongly acid; abrupt, smooth boundary. 12 to 14 inches thick.

B21—18 to 26 inches, dark reddish-brown (5YR 3/4) silty clay loam, yellowish red (5YR 3/6) when dry; moderate, fine, subangular blocky structure; slightly hard, firm, slightly sticky and plastic; few fine roots; many, fine, tubular pores; moderately thick, patchy coatings on all ped faces; common, fine, black concretions; strong effervescence with hydrogen peroxide; medium acid; clear, smooth boundary. 7 to 9 inches thick.

B22—26 to 32 inches, dark reddish-brown (5YR 3/4), moist and dry, silty clay loam; strong, fine, blocky structure; hard, firm, sticky and plastic; common, fine, tubular pores; moderately thick, patchy coatings on ped faces; few black concretions; few, very firm, earthy lumps; very weak effervescence with hydrogen peroxide; medium acid; clear, smooth boundary. 5 to 7 inches thick.

B23—32 to 44 inches, dark reddish-brown (5YR 3/4), moist and dry, silty clay loam; strong, fine and very fine, subangular blocky and angular blocky structure; hard, firm, sticky and plastic; many, fine and very fine, tubular pores; nearly continuous coatings on ped surfaces, many of which look like pressure surfaces; common, fine, earthy lumps; few, fine, black

concretions; many very fine particles of weathered rock; effervescence with hydrogen peroxide limited to the black concretions; medium acid; gradual, wavy boundary. 10 to 15 inches thick.

B3—44 to 57 inches, dark reddish-brown (5YR 3/3) silty clay loam, dark reddish brown (5YR 3/4) when dry; weak, very fine, angular and subangular blocky structure; hard, firm, slightly sticky and plastic; many fine, very fine and medium, tubular pores; thin, patchy pressure cutans on ped faces; many very fine particles of weathered rock; no effervescence with hydrogen peroxide; medium acid; clear, smooth boundary. 11 to 14 inches thick.

C—57 to 60 inches, very dark grayish-brown (10YR 3/2) light silty clay loam, dark brown (10YR 3/3) when dry; weak, very fine, subangular blocky structure; hard, friable, slightly sticky and plastic; few, fine, tubular pores; common, fine, earthy lumps; numerous fragments of saprolite that increase with depth.

The solum ranges from 48 to 65 inches in thickness. The lower boundary is commonly diffuse. The depth to weathered basalt ranges from 3 to 7 feet. The A horizon ranges from 5YR to 7.5YR in hue, and the B horizon 5YR to 7.5YR. The structural grade of the B2 horizon ranges from moderate to strong.

All of this soil is used for pineapple. (Capability classification IIe if irrigated, IVc if nonirrigated; pineapple group 2; pasture group 2)

Uwala silty clay loam, 7 to 15 percent slopes (UwC).—On this soil, runoff is medium and the erosion hazard is moderate. Workability is slightly difficult because of the slope. Included in mapping were a few small, severely eroded areas. These areas have common pebble-size fragments of weathered rock in the surface layer.

This soil is used primarily for pineapple. Small areas are used for wildlife habitat. (Capability classification IIIe if irrigated, IVe if nonirrigated; pineapple group 3; pasture group 2)

Uwala silty clay loam, 7 to 15 percent slopes, severely eroded (UwC3).—On this soil, runoff is medium to rapid and the erosion hazard is severe. In cultivated areas there are many pebble-size fragments of weathered rock in the plow layer. In areas not cultivated, 10 to 25 percent of the surface is covered by erosion scars and there are a few small gullies.

This soil is used for wildlife habitat and pineapple. Most of the area is in grasses and shrubs. In recent years, however, pineapple acreage on Lanai has been expanding, mainly on this soil. (Capability classification IVe, irrigated or nonirrigated; pineapple group 3; pasture group 2)

Very Stony Land

This land type consists of areas where 50 to 90 percent of the surface is covered with stones and boulders. It is mapped on the islands of Maui, Molokai, and Lanai.

Very stony land (rVS).—This land type occurs on Maui, Molokai, and Lanai. The slope ranges from 7 to 30 percent. Included in mapping were very steep gulches.

On Maui, this land type consists of young Aa lava that has a thin covering of volcanic ash that locally extends deep into cracks and depressions. It occurs as large areas, mainly on the upper slopes of Mt. Haleakala at elevations between 4,000 and 9,000 feet. The annual rainfall amounts to 30 to 40 inches. The ash-covered areas support a stand of shrubs and grasses. Puakeawe, Yorkshire foggrass, and orchardgrass are common at the higher elevations. Lantana, kiawe, Natal redtop, and pitted beardgrass are common at the lower elevations.

On Molokai and Lanai, this land type consists of stones and boulders underlain by soft, weathered rock and bedrock. In a few places there is a shallow, clayey soil among the stones and boulders. Elevations range from sea level to 1,500 feet. The annual rainfall amounts to 10 to 25 inches. The natural vegetation consists of kiawe, klu, piligrass, and Japanese tea.

This land type is used for pasture and wildlife habitat. Pasture improvement is very difficult because of the many stones. (Capability classification VIIs, nonirrigated)

Very stony land, eroded (rVT2).—This land type consists of large areas of severely eroded soils on Molokai and Lanai. About 50 to 75 percent of the surface is covered with stones and boulders. There are common shallow gullies and a few deep gullies. The soil material is like that of the Holomua, Molokai, Pamoa, and Waikapu soils. In most places it is less than 24 inches deep to bedrock, but it is deeper in a few low-lying areas. Slopes are mainly 7 to 30 percent, but they range from 3 to 40 percent.

This land type occurs in the same general area as Very stony land, but it is mostly upslope from those areas. Elevations range from sea level to 1,000 feet. The annual rainfall amounts to 10 to 25 inches. This land type supports a thicker stand of vegetation than Very stony land because it has more soil material. The dominant vegetation is kiawe, ilima, piligrass, and fingergrass.

These areas are used for pasture and wildlife habitat. Improvement of pasture is difficult because of the many stones and gullies, and in unimproved areas the carrying capacity is low. The habitat is excellent for axis deer. With a little improvement, excellent habitat for game birds can be established. (Capability classification VIIs, nonirrigated)

Wahiawa Series

This series consists of well-drained soils on uplands on the island of Oahu. These soils developed in residuum and old alluvium derived from basic igneous rock. They are nearly level to moderately steep. Elevations range from 500 to 1,200 feet. Rainfall amounts to 40 to 60 inches annually; most of it occurs between November and April. The mean annual soil temperature is 71° F. Wahiawa soils are geographically associated with Kunia, Lahaina, Leilehua, and Manana soils.

These soils are used for sugarcane, pineapple, pasture, and homesites. The natural vegetation consists of bermudagrass, guava, honohono, koa haole, and lantana.

Wahiawa silty clay, 0 to 3 percent slopes (WaA).—This soil occurs on smooth, broad interfluves. Included in mapping were small areas of Kunia, Lahaina, and Leilehua soils.

In a representative profile the surface layer is very dusky red and dusky red silty clay about 12 inches thick. The subsoil, about 48 inches thick, is dark reddish-brown silty clay that has subangular blocky structure. The underlying material is weathered basic igneous rock. The soil is medium acid in the surface layer and medium acid to neutral in the subsoil.

Permeability is moderately rapid. Runoff is slow, and the erosion hazard is no more than slight. The available water capacity is about 1.3 inches per foot in the surface layer and about 1.4 inches per foot in the subsoil. In places roots penetrate to a depth of 5 feet or more.

Representative profile: Island of Oahu, lat. 21°26′16″ N. and long. 158°00′16″ W.

Ap1—0 to 6 inches, very dusky red (2.5Y 2/2) silty clay, dusky red (2.5YR 3/2) when dry; moderate, medium, fine and very fine, granular structure; very hard, friable, sticky and plastic; abundant roots; many medium, fine and very fine, interstitial pores; many black concretions ⅛ inch to ¼ inch in diameter; violent effervescence with hydrogen peroxide; medium acid; abrupt, smooth boundary. 2 to 6 inches thick.

Ap2—6 to 12 inches, dusky-red (2.5YR 3/2), moist and dry, silty clay; commonly, dark reddish-brown (2.5YR 3/4) material from the B horizon of cultivated soil; moderate, coarse, subangular blocky structure; hard, firm, sticky and plastic; abundant roots; few, fine and very fine, tubular pores; compact in place; many black concretions; violent effervescence with hydrogen peroxide; medium acid; abrupt, wavy boundary. 5 to 8 inches thick.

B21—12 to 16 inches, dark reddish-brown (2.5YR 2/4) silty clay, dark reddish brown (2.5YR 3/4) when dry; moderate, fine and very fine, subangular blocky structure; hard, firm, sticky and plastic; plentiful roots; common, fine and very fine, tubular pores and few, coarse, tubular pores; many black concretions; strong effervescence with hydrogen peroxide; medium acid; gradual, wavy boundary. 4 to 8 inches thick.

B22—16 to 33 inches, dark reddish-brown (2.5YR 2/4) silty clay, dark reddish brown (2.5YR 3/4) when dry; moderate and strong, fine and very fine, subangular blocky structure; hard, friable, sticky and plastic; few roots; common, fine and very fine, tubular pores; nearly continuous pressure cutans; many, fine, distinct, black stains; few black concretions; strong effervescence with hydrogen peroxide; slightly acid; diffuse, wavy boundary. 14 to 20 inches thick.

B23—33 to 45 inches, dark reddish-brown (2.5YR 2/4) silty clay, dark reddish brown (2.5YR 3/4) when dry; moderate and strong, very fine, subangular blocky structure; hard, friable, sticky and plastic; common, fine and very fine, tubular pores; nearly continuous pressure cutans; many, fine, distinct, black stains; few black concretions; moderate effervescence with hydrogen peroxide; neutral; diffuse, wavy boundary. 10 to 14 inches thick.

B24—45 to 60 inches, dark reddish-brown (2.5YR 2/4) silty clay, dark reddish brown (2.5YR 3/4) when dry; moderate and strong, very fine, subangular blocky structure; hard, friable, sticky and plastic; common, fine and very fine, tubular pores; few, fine, black stains; thin, patchy clay films; continuous pressure cutans; many distinct slickensides as much as 2 inches long; very few black concretions; slight effervescence with hydrogen peroxide; neutral.

Black concretions, 2 to 5 millimeters in size, occur on the surface and to a depth of 5 feet or more. The depth to highly weathered basalt ranges from 5 feet to more than 10 feet. A few boulder cores occur in the lower part of the solum in places. The A horizon ranges from 2 to 3 in value and from 2 to 4 in chroma when dry or moist. The B horizon ranges from 2.5YR to 10YR in hue; from 2 to 3 in value when dry or moist; and from 3 to 6 in chroma when dry and from 3 to 5 in chroma when moist.

This soil is used for sugarcane, pineapple, pasture, and homesites. (Capability classification I if irrigated, IIc if nonirrigated; sugarcane group 1; pineapple group 4; pasture group 5; woodland group 5)

Wahiawa silty clay, 3 to 8 percent slopes (WaB).—On this soil, runoff is slow and the erosion hazard is slight. Included in mapping were small areas of nearly level soil.

This soil is used for sugarcane, pineapple, and pasture. (Capability classification IIe, irrigated or nonirrigated; sugarcane group 1; pineapple group 5; pasture group 5; woodland group 5)

Wahiawa silty clay, 8 to 15 percent slopes (WaC).—On this soil, runoff is medium and the erosion hazard is moderate. Included in mapping were small areas that are stony and eroded.

This soil is used for sugarcane and pineapple. (Capability classification IIIe, irrigated or nonirrigated; sugarcane group 1; pineapple group 6; pasture group 5; woodland group 5)

Wahiawa silty clay, 15 to 25 percent slopes, eroded (WaD2).—Most of the surface layer of this soil, and in places part of the subsoil, has been removed by erosion. The profile is otherwise like that of Wahiawa silty clay, 0 to 3 percent slopes. The depth to soft weathered rock ranges from 2 to 3 feet. Boulders occur on the surface in a few places. Runoff is medium to rapid, and the erosion hazard is severe. Tillage is difficult. Included in mapping were small stony areas.

This soil is used for pasture. (Capability classification IVe, nonirrigated; sugarcane group 1; pineapple group 6; pasture group 5; woodland group 5)

Wahikuli Series

This series consists of well-drained soils on uplands on the island of Maui. These soils developed in material weathered from basic igneous rock. They have been influenced to some extent by volcanic ash from local cinder cones. They are gently to moderately sloping. Elevations range from nearly sea level to 600 feet. The annual rainfall amounts to 12 to 20 inches; most of it occurs in winter. The mean annual soil temperature is 75° F. Wahikuli soils are geographically associated with Lahaina and Molokai soils.

These soils are used mostly for sugarcane. A small acreage is used for homesites. The natural vegetation consists of bermudagrass, feather fingergrass, kiawe, and uhaloa.

Wahikuli silty clay, 3 to 7 percent slopes (WbB).—This soil is on smooth, low uplands. Included in mapping were small areas of Lahaina and Molokai soils.

In a representative profile the surface layer is dark reddish-brown silty clay about 15 inches thick. The subsoil, about 17 inches thick, is dark reddish-brown silty clay that has subangular blocky structure. The substratum is hard basic igneous rock. The soil is mildly alkaline in the surface layer and subsoil.

Permeability is moderate. Runoff is slow, and the erosion hazard is slight. The available water capacity is about 1.4 inches per foot in the surface layer and 1.5 inches per foot in the subsoil. In places roots penetrate to bedrock.

Representative profile: Island of Maui, lat. 20°55′09″ N. and long. 156°41′00″ W.

Ap1—0 to 8 inches, dark reddish-brown (2.5YR 3/3) silty clay, dark red (2.5YR 3/6) when dry; weak, fine and

very fine, subangular blocky structure; slightly hard, friable, sticky and plastic; abundant roots; common fine pores; few, fine, black concretions; strong effervescence with hydrogen peroxide; mildly alkaline; gradual, wavy boundary. 6 to 10 inches thick.

Ap2—8 to 15 inches, dark reddish-brown (2.5YR 3/3) silty clay, dark red (2.5YR 3/6) when dry; weak, medium and fine, subangular blocky structure; hard, friable, sticky and plastic; abundant roots; many fine pores; few, fine, black concretions and stains; common sand-size aggregates that are resistant to crushing; strong effervescence with hydrogen peroxide; mildly alkaline; clear, wavy boundary. 5 to 9 inches thick.

B2—15 to 27 inches, dark reddish-brown (2.5YR 3/4) silty clay, dark red (2.5YR 3/6) when dry; weak, medium and fine, subangular blocky structure; slightly hard, friable, sticky and plastic; plentiful roots; many fine and medium pores; few black stains on ped faces and in pores; patchy pressure cutans; few highly weathered pebbles; strong effervescence with hydrogen peroxide; mildly alkaline; gradual, wavy boundary. 10 to 15 inches thick.

B3—27 to 32 inches, dark reddish-brown (2.5YR 3/4) gravelly silty clay, red (2.5YR 4/6) when dry; weak, fine, subangular blocky structure; hard, friable, sticky and plastic; few roots; common fine and medium pores; 30 to 40 percent highly weathered to slightly weathered gravel; few cobblestones; strong effervescence with hydrogen peroxide; mildly alkaline; abrupt, wavy boundary. 4 to 7 inches thick.

R—32 inches, gray, porous basalt that has dark reddish-brown coatings and very little soil material in voids and cracks; in irrigated areas this material is very difficult to grind out with an auger; in dry areas this material is extremely difficult to chip with a spade; very slight effervescence with hydrochloric acid on some rock surfaces.

The depth to bedrock is 20 to 40 inches. The A horizon ranges from 2.5YR to 5YR in hue, and from 2 to 3 in chroma when moist and 3 to 6 when dry. The B horizon ranges from 2.5YR to 5YR in hue and from 3 to 4 in value when dry. In places patchy lime coatings occur in the lower part of the B horizon.

This soil is used for sugarcane. (Capability classification IIe if irrigated, IVs if nonirrigated; sugarcane group 1; pasture group 3)

Wahikuli stony silty clay, 3 to 7 percent slopes (WcB).—This soil is similar to Wahikuli silty clay, 3 to 7 percent slopes, except that there are enough stones on the surface to hinder cultivation.

This soil is used mostly for sugarcane. A small acreage is used for homesites. (Capability classification IIe if irrigated, IVs if nonirrigated; sugarcane group 1; pasture group 3)

Wahikuli stony silty clay, 7 to 15 percent slopes (WcC).—This soil is similar to Wahikuli silty clay, 3 to 7 percent slopes, except that there are enough stones on the surface to hinder cultivation. Runoff is slow to medium, and the erosion hazard is slight to moderate. Included in mapping were small, nonstony areas and some moderately steep areas.

This soil is used mostly for sugarcane. A small acreage is used for homesites. (Capability classification IIIe if irrigated, IVe if nonirrigated; sugarcane group 1; pasture group 3)

Wahikuli very stony silty clay, 3 to 7 percent slopes (WoB).—This soil is similar to Wahikuli silty clay, 3 to 7 percent slopes, except that as much as 3 percent of the surface is covered by stones. Included in mapping were small areas where stones cover 3 to 15 percent of the surface.

This soil is used mostly for sugarcane. A small acreage is used for homesites. (Capability classification IVs if irrigated, VIs if nonirrigated; sugarcane group 1; pasture group 3)

Waiakoa Series

This series consists of well-drained soils on uplands on the island of Maui. These soils developed in material weathered from basic igneous rock. The upper part of the profile is influenced by volcanic ash. These soils are gently sloping to moderately steep. Elevations range from 100 to 1,000 feet. The annual rainfall amounts to 12 to 20 inches; most of it occurs in winter. The mean annual soil temperature is 74° F. Waiakoa soils are geographically associated with Keahua and Keawakapu soils.

These soils are used for sugarcane, pasture, homesites, and wildlife habitat. The natural vegetation consists of buffelgrass, feather fingergrass, ilima, kiawe, uhaloa, and zinnia.

Waiakoa very stony silty clay loam, 3 to 7 percent slopes (WgB).—This soil is on smooth, low uplands. Included in mapping were small areas of Keahua and Keawakapu soils. Also included were small, nearly level areas.

In a representative profile the surface layer is dark reddish-brown silty clay loam about 2 inches thick. The subsoil, about 23 inches thick, is dark reddish-brown and very dark grayish-brown silty clay loam that has prismatic structure or is massive. The substratum is very dark brown silty clay loam and hard, basic igneous rock. The soil is neutral in the surface layer and slightly acid to neutral in the subsoil.

Permeability is moderate. Runoff is slow, and the erosion hazard is slight. The available water capacity is about 1.5 inches per foot of soil. In places roots penetrate to bedrock.

Representative profile: Island of Maui, lat. 20°47′20″ N. and long. 156°24′30″ W.

Ap—0 to 2 inches, dark reddish-brown (5YR 3/3) very stony silty clay loam, reddish brown (5YR 3/4) when dry; moderate, medium and thick, platy structure; hard, friable, sticky and plastic; abundant roots; many fine pores; roots tend to follow plates; 1 to 3 percent stones on surface; strong effervescence with hydrogen peroxide; neutral; abrupt, smooth boundary. 1 to 3 inches thick.

B21—2 to 8 inches, dark reddish-brown (5YR 3/2) silty clay loam, dark reddish brown (5YR 3/4) when dry; weak, coarse, prismatic structure; hard, friable, sticky and plastic; abundant roots; many fine and very fine pores; compact in place except for a few pockets of loose material; 5 percent pebble-size rock fragments; strong, delayed effervescence with hydrogen peroxide; neutral; gradual, wavy boundary. 4 to 8 inches thick.

B22—8 to 16 inches, dark reddish-brown (5YR 3/3) silty clay loam, dark reddish brown (5YR 3/4) when dry; weak, coarse, prismatic structure; hard, friable, sticky and plastic; abundant roots; many fine pores; common sand-size aggregates that are resistant to crushing; 5 percent pebble-size rock fragments; strong, delayed effervescence with hydrogen peroxide; slightly acid; clear, wavy boundary. 6 to 9 inches thick.

IIB23 16 to 25 inches, very dark grayish-brown (10YR 3/2) silty clay loam, dark grayish brown (10YR 4/2) when dry; weak, coarse, prismatic structure in place and weak, medium, subangular blocky structure where disturbed; hard, friable, sticky and plastic, and weakly smeary; plentiful roots; many fine and very fine pores; 20 to 30 percent pebble-size, highly weathered rock fragments; neutral; gradual, wavy boundary. 7 to 12 inches thick.

IIC—25 to 33 inches, very dark brown (10YR 2/2) silty clay loam, very dark grayish brown (10YR 3/2) when dry; massive; hard, friable, sticky and plastic; plentiful roots; very porous; common, hard, earthy lumps; 10 to 20 percent soil material in cracks; 70 to 80 percent grayish-brown (2.5YR 5/2), highly weathered, basic igneous rock; 10 percent hard rock fragments; common black stains on rocks; stains effervesce violently with hydrogen peroxide; neutral.

IIR—33 inches, hard bedrock.

The depth to bedrock ranges from 20 to 40 inches. The A horizon ranges from 5YR to 2.5YR in hue, from 2 to 3 in value when moist or dry, and from 2 to 3 in chroma when moist and 3 to 4 when dry. The B horizon ranges from 5YR to 2.5YR in hue. The upper part of the B2 horizon ranges from 2 to 3 in value when dry and from 2 to 3 in chroma when moist and 3 to 4 when dry. In some areas, calcium carbonate occurs as coatings on the bedrock.

This soil is used for sugarcane, pasture, and wildlife habitat. (Capability classification IVs if irrigated, VIs if nonirrigated; sugarcane group 1; pasture group 1)

Waiakoa very stony silty clay loam, 7 to 15 percent slopes (WgC).—On this soil, runoff is slow to medium and the erosion hazard is slight to moderate.

This soil is used for pasture and wildlife habitat. (Capability classification IVs if irrigated, VIs if nonirrigated; sugarcane group 1; pasture group 1)

Waiakoa silty clay loam, 3 to 7 percent slopes (WeB).—This soil has a profile like that of Waiakoa very stony silty clay loam, 3 to 7 percent slopes, except that it is nonstony. Included in mapping were small, nearly level areas.

This soil is used for sugarcane. Small acreages are used for pasture and homesites. (Capability classification IIe if irrigated, VIs if nonirrigated; sugarcane group 1; pasture group 1)

Waiakoa silty clay loam, 7 to 15 percent slopes (WeC).—This soil has a profile like that of Waiakoa very stony silty clay loam, 3 to 7 percent slopes, except that it is nonstony. Runoff is slow to medium, and the erosion hazard is slight to moderate. Included in mapping were small, moderately steep areas and small areas where cobblestones are on the surface.

This soil is used for sugarcane. (Capability classification IIIe if irrigated, VIe if nonirrigated; sugarcane group 1; pasture group 1)

Waiakoa cobbly silty clay loam, 3 to 7 percent slopes (WfB).—This soil is similar to Waiakoa very stony silty clay loam, 3 to 7 percent slopes, except that it is cobbly on the surface.

This soil is used for sugarcane. (Capability classification IIe if irrigated, VIs if nonirrigated; sugarcane group 1; pasture group 1)

Waiakoa extremely stony silty clay loam, 3 to 7 percent slopes (WhB).—This soil is similar to Waiakoa very stony silty clay loam, 3 to 7 percent slopes, except that stones cover 3 to 15 percent of the surface. Included in mapping were small, nearly level areas.

This soil is used for sugarcane, pasture, and wildlife habitat. (Capability classification VIIs, nonirrigated; pasture group 1)

Waiakoa extremely stony silty clay loam, 7 to 15 percent slopes (WhC).—This soil is similar to Waiakoa very stony silty clay loam, 3 to 7 percent slopes, except that stones cover 3 to 15 percent of the surface. Runoff is slow to medium, and the erosion hazard is slight to moderate.

This soil is used for pasture and wildlife habitat. (Capability classification VIIs, nonirrigated; pasture group 1)

Waiakoa extremely stony silty clay loam, 3 to 25 percent slopes, eroded (WlD2).—This soil is similar to Waiakoa very stony silty clay loam, 3 to 7 percent slopes, except that it is eroded and stones cover 3 to 15 percent of the surface. In most areas about 50 percent of the surface layer has been removed by erosion. Runoff is medium, and the erosion hazard is severe. Included in mapping were small, steep areas. Also included were a few cinder cones.

This soil is used for pasture and wildlife habitat. (Capability classification VIIs, nonirrigated; pasture group 1)

Waialeale Series

This series consists of somewhat poorly drained soils on uplands on the island of Kauai. These soils developed in material weathered from basic igneous rock. They are very steep. Elevations range from 3,500 to 4,800 feet. The annual rainfall amounts to 100 to 450 inches. The mean annual soil temperature is 56° F. Waialeale soils are geographically associated with Alakai soils.

These soils are used for water supply and wildlife habitat. The natural vegetation consists of ohia, lapalapa, Hawaiian lobelia, mokihana, puakeawe, treefern, brackenfern, uki uki, and associated plants.

Waialeale mucky silty clay loam, 30 to 70 percent slopes (rWAF).—This soil is on high upland slopes. Included in mapping were small areas that have an ironstone sheet in the B horizon.

In a representative profile the surface layer, about 3 inches thick, is dark reddish-brown, massive mucky peat. This is underlain by about 4 inches of dark-gray silty clay loam that has subangular blocky structure. The subsoil, about 17 inches thick, is strong-brown, gravelly silty clay loam that has subangular blocky structure. The substratum is hard and soft, weathered rock.

Permeability is moderately rapid. Runoff is rapid, and the erosion hazard is severe. Roots penetrate to the weathered rock.

Representative profile: Island of Kauai, lat. 22°09′02″ N. and long. 159°37′7.5″ W.

O2—3 inches to 0, dark reddish-brown (5YR 2/2) mucky peat, dark reddish brown (5YR 2/2) when dry; massive; slightly hard, friable, slightly sticky and slightly plastic; plentiful roots; moderate, delayed effervescence with hydrogen peroxide; extremely acid; abrupt, smooth boundary. 2 to 6 inches thick.

A2g—0 to 4 inches, dark-gray (5YR 4/1) silty clay loam, gray (10YR 5/1) when dry; weak, fine, subangular blocky structure; hard, friable, sticky and plastic; abundant roots; very slight, delayed effervescence with hydrogen peroxide; a few, fine, ironstone-

gibbsite pebbles that have soft centers; extremely acid; clear, wavy boundary. 3 to 7 inches thick.

B2ir—4 to 21 inches, strong-brown (7.5YR 4/6) gravelly silty clay loam, dark reddish brown (5YR 3/4) when dry; weak, fine, subangular blocky structure; hard, friable, sticky and plastic, and smeary; few roots; coatings of reddish black (10R 2/1) in some pores and on some pebbles; pockets of dark reddish-brown (5YR 3/2) silt loam, as much as 8 inches thick, that is very friable, slightly sticky and slightly plastic; no effervescence with hydrogen peroxide; the amount of gravel increases with depth; extremely acid; gradual, irregular boundary. 4 to 18 inches thick.

C&R—21 inches, this layer consists of soft and hard saprolite that is dominantly gray (N 5/0); some coatings and pockets of strong brown (7.5YR 5/6); soft saprolite is very smeary; hard saprolite is fractured.

The A horizon ranges from 5YR to 10YR in hue. The B2 horizon ranges from 4 to 6 in chroma. It ranges from gravelly silty clay loam to silty clay in texture. The amount of gravel in the B2 horizon ranges from 5 to 50 percent.

This soil is used for water supply and wildlife habitat. (Capability classification VIIe, nonirrigated; woodland group 16)

Waialua Series

This series consists of moderately well drained soils on alluvial fans on the island of Oahu. These soils developed in alluvium weathered from basic igneous rock. They are nearly level to steep. Elevations range from 10 to 100 feet. The annual rainfall amounts to 25 to 50 inches; most of it occurs between November and April. The mean annual soil temperature is 73° F. Waialua soils are geographically associated with Honouliuli, Kaena, and Kawaihapai soils.

These soils are used for sugarcane, truck crops, orchards, and pasture. The natural vegetation is swollen fingergrass, koa haole, and uhaloa.

Waialua silty clay, 0 to 3 percent slopes (WkA).—This soil is on smooth coastal plains. Included in mapping were small areas of Honouliuli, Kaena, and Kawaihapai soils. Also included were small areas that are gravelly.

In a representative profile the surface layer is dark reddish-brown silty clay about 12 inches thick. The subsoil, about 26 inches thick, is dark reddish-brown and reddish-brown silty clay that has subangular blocky structure. The substratum is dark reddish-brown, mottled silty clay. The soil is neutral in the surface layer and slightly acid in the subsoil.

Permeability is moderate. Runoff is slow, and the erosion hazard is no more than slight. The available water capacity is about 1.8 inches per foot in the surface layer and 1.6 inches per foot in the subsoil. In places roots penetrate to a depth of 5 feet or more.

Representative profile: Island of Oahu, lat. 21°34′03″ N. and long. 158°08′39″ W.

Ap—0 to 12 inches, dark reddish-brown (5YR 3/2) silty clay, dark reddish brown (5YR 3/3) when dry; moderate, medium and coarse, subangular blocky structure; very hard, firm, very sticky and very plastic; abundant very fine roots; common, very fine and fine, interstitial and tubular pores; thin layer of moderate, very fine, and fine granules on surface; common, fine, black concretions; strong effervescence with hydrogen peroxide; neutral; clear, wavy boundary. 5 to 15 inches thick.

B21—12 to 20 inches, dark reddish-brown (5YR 3/2) silty clay, dark reddish brown (5YR 3/3) when dry; moderate, fine and medium, subangular blocky structure; very hard, friable, very sticky and very plastic; abundant very fine and fine roots and few medium roots; common, fine and medium, tubular pores; few, fine, black concretions; strong effervescence with hydrogen peroxide; slightly acid; clear, wavy boundary. 6 to 8 inches thick.

B22—20 to 30 inches, reddish-brown (5YR 3/3) silty clay, dark reddish brown (5YR 4/3) when dry; weak, medium and coarse, subangular blocky structure; very hard, friable, very sticky and very plastic; abundant fine roots; many, fine, tubular pores; common thin clay films in pores; few black concretions; strong effervescence with hydrogen peroxide; slightly acid; clear, wavy boundary. 8 to 12 inches thick.

B23—30 to 38 inches, dark reddish-brown (5YR 3/3) silty clay; common, medium, distinct, dark-red (2.5YR 3/6) mottles; dark reddish brown (5YR 3/4) when dry; weak, medium and coarse, subangular blocky structure; very hard, friable, very sticky and very plastic; abundant fine roots; many, fine, tubular pores; thin, patchy clay films in pores and on ped faces; abundant, fine, black concretions; black stains 2 to 5 millimeters wide; strong effervescence with hydrogen peroxide; slightly acid; clear, smooth boundary. 6 to 10 inches thick.

C—38 to 55 inches, dark reddish-brown (5YR 3/3) silty clay; common, medium, distinct, dark-red (2.5YR 3/6) mottles; dark reddish brown (5YR 3/4) when dry; weak, coarse, subangular blocky structure; very hard, friable, very sticky and very plastic; few fine roots; common, fine, tubular pores; few, fine, black concretions; black stains 2 to 5 millimeters wide; slight effervescence with hydrogen peroxide; slightly acid.

In places fine black concretions occur throughout the solum. Reaction ranges from slightly acid to neutral. The amount of highly weathered cobblestones and pebbles in the profile ranges from 5 to 30 percent. The plasticity of the clay ranges from very sticky and very plastic at the lower elevations to sticky and plastic at the higher elevations. The solum ranges from 5YR to 10YR in hue. Silty clay and clay types are mapped. The A horizon ranges from 2 to 3 in value when moist and from 3 to 4 when dry. It ranges from 1 to 2 in chroma when moist and from 2 to 4 when dry. The B horizon ranges from weak to moderate in structure.

This soil is used for sugarcane, truck crops, and pasture. (Capability classification I if irrigated, IIIc if nonirrigated; sugarcane group 4; pasture group 3; woodland group 1)

Waialua silty clay, 3 to 8 percent slopes (WkB).—On this soil, runoff is slow and the erosion hazard is slight.

This soil is used for sugarcane, truck crops, and pasture. (Capability classification IIe if irrigated, IIIc if nonirrigated; sugarcane group 4; pasture group 3; woodland group 1)

Waialua stony silty clay, 3 to 8 percent slopes (WlB).—This soil has a profile like that of Waialua silty clay, 0 to 3 percent slopes, except that there are sufficient stones to hinder tillage but not enough to make intertilled crops impractical. Runoff is slow, and the erosion hazard is slight. Workability is slightly difficult. Included in mapping were small, nonstony areas and small, moderately sloping areas.

This soil is used for sugarcane, truck crops, orchards, and pasture. (Capability classification IIIe if irrigated, IIIs if nonirrigated; sugarcane group 4; pasture group 3; woodland group 1)

Waialua stony silty clay, 12 to 30 percent slopes (WzE).—This soil has a profile like that of Waialua silty clay, 0 to 3 percent slopes, except that there are sufficient stones to hinder tillage but not enough to make intertilled crops impractical. Runoff is medium to rapid, and the erosion hazard is moderate to severe. Workability is difficult. Included in mapping were small areas of steep stony land, talus slopes, and eroded spots.

This soil is used for pasture. (Capability classification IVe, nonirrigated; pasture group 3; woodland group 1)

Waialua very stony silty clay, 12 to 20 percent slopes (WmD).—This soil is similar to Waialua silty clay, 0 to 3 percent slopes, except that stones cover as much as 3 percent of the surface. Runoff is medium, and the erosion hazard is moderate. Workability is difficult. Included in mapping were areas of stony land and eroded spots.

This soil is used for pasture. (Capability classification VIs, nonirrigated; pasture group 3; woodland group 1)

Waialua clay, 2 to 6 percent slopes (WnB).—On this soil, runoff is slow and the erosion hazard is slight. The available water capacity is about 1.4 inches per foot in the surface layer and 1.6 inches per foot in the subsoil. Workability is slightly difficult. Included in mapping were small areas that are nearly level, gravelly, or stony. Also included were small areas of wet soils.

This soil is used for truck crops, orchards, and pasture. (Capability classification IIe if irrigated, IIIc if nonirrigated; sugarcane group 4; pasture group 3; woodland group 1)

Waiawa Series

This series consists of well-drained, very shallow, extremely rocky soils on uplands on the island of Kauai. These soils developed in colluvium and in material weathered from basic igneous rock. They are steep to very steep. Elevations range from nearly sea level to about 2,000 feet. The annual rainfall amounts to 22 to 40 inches. The mean annual soil temperature is 74° F. Waiawa soils are geographically associated with Makaweli and Niu soils.

These soils are used for pasture, wildlife habitat, and water supply. The natural vegetation consists of koa haole, pricklypear cactus, klu, feather fingergrass, lantana, and piligrass.

Waiawa extremely rocky clay, 30 to 80 percent slopes (WJF).—This soil occurs on slopes of gulches in the uplands. Rock outcrop covers 25 to 50 percent of the surface.

In a representative profile the surface layer is dark reddish-brown, strong, granular heavy clay loam about 2 inches thick. This layer is underlain by dark reddish-brown clay about 12 inches thick. It has angular blocky structure. The substratum is hard rock. The soil is slightly acid to neutral throughout the profile.

Permeability is moderate to moderately slow. Runoff is very rapid, and the erosion hazard is severe. Roots penetrate to bedrock and follow cracks in the rock.

Representative profile: Island of Kauai, lat. 21°59′22.3″ N. and long. 159°43′15.3″ W.

A11—0 to 2 inches, dark reddish-brown (5YR 3/2) heavy clay loam, dark reddish brown (5YR 3/4) when rubbed, dark reddish brown (5YR 3/3) when dry; strong, very fine, granular structure; slightly hard, friable, sticky and plastic; abundant coarse, medium, fine, very fine, and micro roots; moderate effervescence with hydrogen peroxide; slightly acid; clear, smooth boundary. ½ inch to 3 inches thick.

A12—2 to 14 inches, dark reddish-brown (5YR 3/4) clay, dark reddish brown (5YR 3/4) when rubbed, dark reddish brown (5YR 3/3) when dry; moderate, coarse, angular blocky structure; very hard, very firm, sticky and plastic; abundant coarse, medium, and micro roots and plentiful fine and very fine roots; shiny pressure cutans and slickensides on some peds; moderate effervescence with hydrogen peroxide; neutral; abrupt, irregular boundary. 6 to 12 inches thick.

R—14 inches, basalt rock. Soil and roots in cracks.

The soil color ranges from 2 to 4 in chroma. The soil depth ranges from 6 to 15 inches.

This soil is used for pasture or is idle. (Capability classification VIIs, nonirrigated; pasture group 2)

Waihuna Series

This series consists of well drained and moderately well drained soils on alluvial fans and in depressions on the islands of Lanai and Molokai. These soils formed in old, fine-textured alluvium. They are nearly level to moderately steep. Elevations are mainly between 1,000 and 2,000 feet, but they range from 400 to 2,000 feet. The annual rainfall amounts to 20 to 35 inches; most of it occurs between November and April. The mean annual soil temperature is 69° F. Waihuna soils are geographically associated with Lahaina, Kalae, and Hoolehua soils.

These soils are used for pineapple, pasture, and wildlife habitat. The natural vegetation is Natal redtop, lantana, and guineagrass.

Waihuna clay, 0 to 3 percent slopes (WoA).—This is the most extensive soil in the Waihuna series. It occurs on Lanai, mainly as two large areas. Included in mapping were small areas that are subject to ponding. These areas are in the central part of the Palawai Basin and in other depressions. In some years water remains in these depressions long enough to damage crops or interfere with farming operations.

In a representative profile the surface layer, about 18 inches thick, is dark-brown, very sticky and very plastic clay. The next layer, 40 to more than 50 inches thick, is dark-brown, very sticky and very plastic clay and silty clay that has subangular blocky structure. This is underlain by relatively soft, weathered pebbles and stones. The soil is strongly acid in the surface layer as a result of pineapple culture, but it is neutral to medium acid in the rest of the profile. Cracks, ½ inch to 1 inch wide, form when the soil dries.

Permeability is moderately slow. Runoff is slow, and the erosion hazard is no more than slight. The available water capacity is about 1.3 inches per foot of soil. In places roots penetrate to a depth of 5 feet or more. This soil is difficult to work because it is very sticky and very plastic when wet.

Representative profile: Island of Lanai, lat. 20°49′52″ N. and long. 156°55′58″ W.

Ap1—0 to 1 inch, very dark grayish-brown (10YR 3/2), moist and dry, clay; strong, very fine and fine, granular structure; hard, friable, very sticky and very plastic; violent effervescence with hydrogen peroxide; strongly acid; clear, smooth boundary. ½ inch to 2 inches thick.

Ap2—1 inch to 6 inches, dark-brown (10YR 3/3) clay, dark yellowish brown (10YR 3/4) when dry; moderate, very fine, granular structure; very hard, friable, very sticky and very plastic; many interstitial pores; cracks as much as 1 inch wide develop upon drying; many variegated sand grains can be seen under a hand lens; common plant remains that have been plowed under; violent effervescence with hydrogen peroxide; strongly acid; clear, smooth boundary. 5 to 6 inches thick.

Ap3—6 to 12 inches, dark-brown (7.5YR 3/2), moist and dry, clay; massive; hard, friable, very sticky and very plastic; few, very fine, tubular pores; cracks as much as 1 inch wide develop upon drying; many plant remains that have been plowed under; many variegated sand grains can be seen under a hand lens; violent effervescence with hydrogen peroxide; strongly acid; clear, smooth boundary. 5 to 6 inches thick.

Ap4—12 to 18 inches, dark-brown (10YR 3/3) clay, dark yellowish brown (10YR 3/4) when dry; weak, very fine, subangular blocky structure; very hard, friable, very sticky and very plastic; common pores; cracks as much as 1 inch wide develop upon drying; common plant remains that have been plowed under; many variegated sand grains can be seen under a hand lens; a few highly weathered pebbles; violent effervescence with hydrogen peroxide; strongly acid; clear, smooth boundary. 6 to 7 inches thick.

AC—18 to 25 inches, dark-brown (10YR 3/3), moist and dry, clay; weak, coarse, prismatic structure breaking to moderate, very fine and fine, subangular blocky; very hard, firm, very sticky and very plastic; no roots; common pores; common pressure cutans; some are weakly grooved; few highly weathered pebbles; many variegated sand grains can be seen under a hand lens; firm in place; violent effervescence with hydrogen peroxide; medium acid; gradual, wavy boundary. 7 to 8 inches thick.

C1—25 to 41 inches, dark-brown (7.5YR 3/2), moist and dry, clay; strong, very fine, subangular blocky structure; very hard, firm, very sticky and very plastic; no roots; common pores; many variegated sand grains can be seen under a hand lens; few highly weathered pebbles; common pressure cutans; few slickensides; strong effervescence with hydrogen peroxide; neutral; clear, smooth boundary. 15 to 17 inches thick.

C2—41 to 53 inches, dark-brown (7.5YR 3/2), moist and dry, clay; moderate, very fine and fine, subangular blocky structure; very hard, firm, very sticky and very plastic; no roots; many, very fine, tubular pores; many variegated sand grains can be seen under a hand lens; common highly weathered pebbles; common pressure cutans; strong effervescence with hydrogen peroxide; slightly acid; gradual, wavy boundary. 11 to 12 inches thick.

C3—53 to 65 inches, dark-brown (7.5YR 3/2), moist and dry, silty clay; moderate, very fine and fine, subangular blocky structure; hard, firm, very sticky and very plastic; no roots; many, very fine and fine, tubular pores and few, coarse, tubular pores; common patchy pressure cutans; common manganese stains; many variegated sand grains, more than in the horizons above; common highly weathered pebbles; strong effervescence with hydrogen peroxide; slightly acid.

In some areas weathered gravel and cobblestones are scattered throughout the profile. A strong granular surface mulch, ½ inch to 2 inches thick, develops upon drying. Cracks ½ inch to 1 inch wide form to a depth of more than 20 inches when the soil dries. The A horizon ranges from 10YR to 7.5YR in hue and from 2 to 3 in chroma. In most places the soil color is yellowest near the source of alluvium and is somewhat redder as distance from the source increases. Texture of the lower part of the C horizon ranges from silty clay to clay. In places few to common mottles occur in the lower part of the profile.

This soil is used for pineapple. (Capability classification IIs if irrigated, IIIs if nonirrigated; pineapple group 1; pasture group 3)

Waihuna clay, 3 to 7 percent slopes (WoB).—This soil occurs on Molokai and Lanai. Runoff is slow, and the erosion hazard is slight.

This soil is used for pineapple. (Capability classification IIe if irrigated, IIIs if nonirrigated; pineapple group 2; pasture group 3)

Waihuna clay, 7 to 15 percent slopes (WoC).—This soil occurs on Molokai and Lanai. Runoff is slow to medium, and the erosion hazard is slight to moderate. Included in mapping were small, gravelly areas.

This soil is used for pineapple, pasture, and wildlife habitat. (Capability classification IIIe, irrigated or nonirrigated; pineapple group 3; pasture group 3)

Waihuna clay, 15 to 25 percent slopes (WoD).—This soil occurs as narrow bands along sharp slope breaks and on foot slopes. Runoff is medium, and the erosion hazard is moderate. In a few places the texture of the surface layer is silty clay.

Most of this soil is used for pasture and wildlife habitat. Small areas on Molokai are used for pineapple. (Capability classification IVe, irrigated or nonirrigated; pineapple group 3; pasture group 3)

Waihuna gravelly clay, 3 to 7 percent slopes (WohB).—This soil is on Lanai, mainly in two areas at the mouth of drainageways. It is similar to Waihuna clay, 0 to 3 percent slopes, except that gravel makes up 15 to 30 percent of the surface layer.

This soil is used for pineapple. (Capability classification IIe if irrigated; IIIs if nonirrigated; pineapple group 2; pasture group 3)

Waikane Series

This series consists of well-drained soils on alluvial fans and terraces on the island of Oahu. These soils developed in alluvium and colluvium derived from basic igneous rock. They are nearly level to very steep. Elevations range from 200 to 1,000 feet. The annual rainfall amounts to 50 to 70 inches. It is well distributed throughout the year. The mean annual soil temperature is 71° F. Waikane soils are geographically associated with Alaeloa, Kaneohe, Lolekaa, and Paumalu soils.

These soils are used for pasture, truck crops, and homesites. The natural vegetation consists of Christmas berry, guava, hilograss, and ricegrass.

Waikane silty clay, 25 to 40 percent slopes (WpE).—This soil is on steep terraces and alluvial fans. Included in mapping were small areas of Alaeloa, Kaneohe, and Lolekaa soils. Also included were small, eroded spots and moderately steep areas.

In a representative profile the surface layer is dark-brown silty clay about 8 inches thick. The subsoil, about 52 inches thick, is dark reddish-brown silty clay that has subangular blocky structure. The substratum is soft, weathered, gravelly alluvium and colluvium. The soil is very strongly acid in the surface layer and subsoil.

Permeability is moderately rapid. Runoff is medium to rapid, and the erosion hazard is moderate to severe. The available water capacity is about 1.1 inches per foot in the surface layer and 1.3 inches per foot in the subsoil. In

places roots penetrate to a depth of 5 feet or more. Workability is difficult.

Representative profile: Island of Oahu, lat. 21°32′04″ N. and long. 157°51′30″ W.

Ap—0 to 8 inches, dark-brown (7.5YR 3/2) silty clay, dark brown (7.5YR 3/4) when dry; strong, fine and very fine, subangular blocky structure; very hard, firm, sticky and plastic; abundant very fine and fine roots; many, very fine and fine, tubular pores; many wormholes and worm casts; very slight effervescence with hydrogen peroxide; very strongly acid; abrupt, smooth boundary. 6 to 9 inches thick.

B21—8 to 19 inches, dark reddish-brown (5YR 3/3) silty clay, dark reddish brown (5YR 3/4) when dry; moderate, medium, subangular blocky structure; hard, firm, sticky and plastic; abundant very fine and fine roots; many, very fine and fine, tubular pores; common, patchy coatings on peds; few, hard, earthy lumps; very strongly acid; gradual, smooth boundary. 6 to 11 inches thick.

B22t—19 to 31 inches, dark reddish-brown (5YR 3/3) silty clay, dark reddish brown (5YR 3/4) when dry; moderate, fine and very fine, subangular blocky structure; hard, firm, sticky and plastic; plentiful fine roots; common, very fine and fine, tubular pores; common, dark-red (2.5YR 3/6), thin, continuous clay films on peds and within pores; few highly weathered pebbles; very strongly acid; clear, smooth boundary. 7 to 12 inches thick.

B23t—31 to 60 inches, dark reddish-brown (5YR 3/3) silty clay, dark reddish brown (5YR 3/4) when dry; few fine roots; common, fine, tubular pores; thin, continuous, dark-red (2.5YR 3/6) clay films on peds and in pores; common highly weathered pebbles; very strongly acid.

The content of highly weathered gravel in the solum increases with depth; it ranges from 5 percent in the upper part to 40 percent in the lower part. The A horizon ranges from 7.5YR to 10YR in hue, from 2 to 3 in value, and from 2 to 4 in chroma when moist. The B horizon ranges from 5YR to 7.5YR in hue and from 3 to 4 in value when moist.

This soil is used for pasture. (Capability classification VIe, nonirrigated; pasture group 8; woodland group 7)

Waikane silty clay, 3 to 8 percent slopes (WpB).—On this soil, runoff is slow and the erosion hazard is slight. Workability is easy. Included in mapping were small, nearly level areas.

This soil is used for truck crops, pasture, and homesites. (Capability classification IIe, irrigated or nonirrigated; pasture group 8; woodland group 7)

Waikane silty clay, 8 to 15 percent slopes (WpC).—On this soil, runoff is slow to medium and the erosion hazard is slight to moderate. Workability is slightly difficult.

This soil is used for truck crops, pasture, and homesites. (Capability classification IIIe, irrigated or nonirrigated; pasture group 8; woodland group 7)

Waikane silty clay, 40 to 70 percent slopes (WpF).—On this soil, runoff is rapid to very rapid and the erosion hazard is severe. Included in mapping were small areas of eroded spots, rock outcrop, and stony areas.

This soil is used for pasture and woodland. (Capability classification VIIe, nonirrigated; pasture group 8; woodland group 14)

Waikane silty clay, 40 to 70 percent slopes, eroded (WpF2).—This soil is similar to Waikane silty clay, 25 to 40 percent slopes, except that it is very steep. Most of the surface layer and, in places, part of the subsoil have been removed by erosion. In a few areas soft, weathered rock is exposed. Runoff is rapid to very rapid, and the erosion hazard is very severe. Included in mapping were small, uneroded areas and small areas of rock outcrop.

This soil is used for pasture and woodland. (Capability classification VIIe, nonirrigated; pasture group 8; woodland group 14)

Waikane stony silty clay, 15 to 30 percent slopes (WpoE).—On this soil, runoff is medium to rapid and the erosion hazard is moderate to severe. Workability is difficult. Included in mapping were small areas where the slope is as much as 40 percent.

This soil is used for pasture. (Capability classification VIe, nonirrigated; pasture group 8; woodland group 7)

Waikapu Series

This series consists of well-drained soils on uplands on the islands of Lanai and Molokai. These soils formed in fine-textured old alluvium. They are nearly level to moderately sloping. Elevations range from 100 to 1,250 feet. The annual rainfall amounts to 15 to 25 inches, most of which occurs from November to April. The mean annual soil temperature is 73° F. Waikapu soils are geographically associated with Holomua, Molokai, and Uwala soils.

These soils are used for pineapple, pasture, and wildlife habitat. The natural vegetation consists of lantana, bermudagrass, ilima, and feather fingergrass.

Waikapu silty clay loam, 0 to 3 percent slopes (WrA).—This soil is on uplands in depressions on old alluvial fans. Included in mapping was an area, about 150 acres in size, that is severely eroded. This area is 1½ miles southwest of Molokai Airport. There are a few stones on the surface and a few shallow gullies.

In a representative profile the surface layer and the subsoil are dark reddish-brown, friable silty clay loam. The surface layer is about 12 inches thick. The subsoil, about 48 inches thick, has subangular and angular blocky structure. The soil is typically slightly acid to neutral but is strongly acid to very strongly acid in the surface layer in areas where pineapple is grown.

Permeability is moderate. Runoff is slow, and the erosion hazard is slight. The available water capacity is about 1.4 inches per foot of soil. In places roots penetrate to a depth of 5 feet or more.

Representative profile: Island of Lanai, lat. 20°47′13″ N. and long. 156°56′12″ W.

Ap1—0 to 4 inches, dark reddish-brown (5YR 2/3 moist, 3/3 dry) silty clay loam; weak, very fine, granular structure; soft, very friable, sticky and plastic; few roots; many interstitial pores and common, very fine, vertical, tubular pores; many, fine, black concretions; violent effervescence with hydrogen peroxide; strongly acid; clear, wavy boundary. 3 to 5 inches thick.

Ap2—4 to 12 inches, dark reddish-brown (5YR 2/3) heavy silt loam or light silty clay loam, reddish brown (5YR 4/4) when dry; weak, medium and fine, subangular blocky structure and some pockets of weak, very fine, granular structure; soft, friable, sticky and plastic; many roots; many, very fine, tubular pores and few, fine, tubular pores; common, fine, black concretions; violent effervescence with hydrogen peroxide; slightly acid; gradual, wavy boundary. 7 to 10 inches thick.

B1 12 to 24 inches, dark reddish-brown (2.5YR 3/4) silty clay loam, reddish brown (2.5YR 4/4) when dry; strong, fine and very fine, angular and subangular blocky structure; slightly hard, friable, sticky and

plastic; few roots; many, very fine and fine, tubular pores and few, medium, tubular pores; patchy glaze on ped faces; firm in place; common, fine, black concretions; violent effervescence with hydrogen peroxide; common, fine, hard, earthy lumps that disappear slowly when rubbed; neutral; gradual, wavy boundary. 10 to 14 inches thick.

B21—24 to 34 inches, dark reddish-brown (2.5YR 3/4), moist and dry, silty clay loam; moderate, medium, subangular blocky structure breaking to strong, fine and very fine, angular blocky; soft, friable, sticky and plastic; many, very fine and fine, tubular pores and few, medium, tubular pores; moderately firm in place; weakly developed, patchy pressure cutans; many, fine, black concretions commonly as much as 2 millimeters in diameter; violent effervescence with hydrogen peroxide; neutral; gradual, wavy boundary. 8 to 12 inches thick.

B22—34 to 44 inches, dark reddish-brown (5YR 3/3 moist, 5YR 3/4 dry) silty clay loam; weak, medium and fine, subangular blocky structure; soft, very friable, sticky and plastic; many, very fine and fine, tubular pores and common, medium, tubular pores; few weakly grooved slickensides; many black concretions; violent effervescence with hydrogen peroxide; neutral; clear, wavy boundary. 8 to 12 inches thick.

B3—44 to 60 inches, dark-red (2.5YR 2/6) silty clay loam, dark reddish brown (2.5YR 3/4) when dry; weak, medium, subangular blocky structure breaking to moderate, fine and very fine, subangular blocky; soft, friable, sticky and plastic; many, very fine and fine, tubular pores and common, medium, tubular pores; patchy glaze on some peds; common, fine, hard, earthy lumps that disappear when persistently rubbed; few slickensides; few, fine, black concretions; slight effervescence with hydrogen peroxide; neutral.

Black concretions that range from fine specks to 3 millimeters in size occur throughout the solum. Effervescence with hydrogen peroxide ranges from strong to violent in the A and B2 horizons. The solum ranges from 5YR to 2.5YR in hue. The A horizon ranges from 2 to 3 in value and chroma when moist and from 3 to 4 in value when dry. The B horizon ranges from 2 to 3 in value when moist and from 3 to 4 when dry. It ranges from 3 to 6 in chroma when moist. Slickensides range from few to common in the lower part of the B horizon.

This soil is used for pineapple, pasture, and wildlife habitat. (Capability classification I if irrigated, IVc if nonirrigated; pineapple group 1; pasture group 2)

Waikapu silty clay loam, 3 to 7 percent slopes (WrB).—This soil is on smooth alluvial fans on Molokai. Runoff is slow, and the erosion hazard is slight to moderate. Included in mapping were small areas where the slope is 7 to 15 percent.

This soil is used for pineapple, pasture, and wildlife habitat. (Capability classification IIe if irrigated, IVc if nonirrigated; pineapple group 2; pasture group 2)

Waikapu silty clay loam, 3 to 7 percent slopes, severely eroded (WrB3).—This soil occurs as two areas in the northwestern part of the Hoolehua Plains on Molokai. It is similar to Waikapu silty clay loam, 0 to 3 percent slopes, except that it is severely eroded. Most of the surface layer and, in many places, part of the subsoil have been removed by erosion. The erosion is caused by strong winds, as well as by water. There are a few bare blown-out spots. Runoff is medium, and the hazard of wind and water erosion is severe.

This soil is used for pasture and wildlife habitat. (Capability classification IIIe if irrigated, IVe if nonirrigated; pineapple group 2; pasture group 2)

Waikapu silty clay loam, 7 to 15 percent slopes, severely eroded (WrC3).—This soil is similar to Waikapu silty clay loam, 0 to 3 percent slopes, except that it is severely eroded. Runoff is medium, and the hazard of wind and water erosion is severe. Most of the topsoil and, in most places, part of the subsoil have been removed by erosion. Moderately deep gullies occur in many areas.

This soil is used for pasture and wildlife habitat. (Capability classification IVe, irrigated or nonirrigated; pineapple group 3; pasture group 2)

Waikomo Series

This series consists of well-drained, stony and rocky soils on uplands on the island of Kauai. These soils developed in material weathered from basic igneous rock, probably with a mixture of ash and alluvium in places. These soils are gently sloping. Elevations range from nearly sea level to 360 feet. The annual rainfall amounts to 35 to 60 inches. The mean annual soil temperature is 74° F. Waikomo soils are geographically associated with Koloa soils.

These soils are used for sugarcane, pasture, wildlife habitat, and homesites. The natural vegetation consists of lantana, koa haole, Java plum, pricklypear cactus, swollen fingergrass, bermudagrass, and guineagrass.

Waikomo stony silty clay (Ws).—This soil is on low uplands. The slope ranges from 2 to 6 percent. Included in mapping were small areas where the slope is as much as 12 percent. Also included were some soils that have a hue of 5YR in the A horizon and 2.5YR in the B horizon.

In a representative profile the surface layer is very dark grayish-brown stony silty clay about 14 inches thick. The subsoil, about 6 inches thick, is reddish-brown stony heavy silty clay loam that has subangular and angular blocky structure. The substratum is hard rock. The soil is neutral to mildly alkaline throughout.

Permeability is moderate. Runoff is slow, and the erosion hazard is slight. The available water capacity is about 1.0 inch per foot of soil. Except for cracks in the rock, roots penetrate to a depth of no more than 20 inches.

Representative profile: Island of Kauai, lat. 21°54′41.2″ N. and long. 159°26′47″ W.

Ap—0 to 14 inches, very dark grayish-brown (10YR 3/2) stony silty clay, dark brown (7.5YR 3/2) when dry; weak, fine and very fine, subangular blocky structure; very hard, very firm, sticky and plastic; abundant medium, fine, and very fine roots; stones makes up about 25 percent of the volume; moderate effervescence with hydrogen peroxide; neutral; clear, smooth boundary. 12 to 16 inches thick.

B2—14 to 20 inches, reddish-brown (5YR 4/4) stony heavy silty clay loam, reddish brown (5YR 4/4) when rubbed and dry; moderate, fine and very fine, subangular and angular blocky structure; very hard, firm, sticky and plastic; plentiful medium, fine, and very fine roots; common medium and fine pores and many very fine pores; stones make up about 25 percent of the volume; thin, discontinuous coatings on ped faces; coatings look like clay films; when dry, peds are nearly covered with yellowish-brown, sugar-like coatings; many very fine, dark reddish-brown concretions that effervesce with hydrogen peroxide; concretions are hard to very hard; slight to moderate effervescence with hydrogen peroxide; mildly

alkaline; abrupt, irregular boundary. 4 to 10 inches thick.

B3&R—20 inches, this layer consists of cracked and broken pahoehoe rock that contains soil material in the few cracks. The soil material is dark-brown (7.5YR 4/4) heavy silty clay loam, strong brown (7.5YR 5/6) when dry; weak, very fine, subangular blocky structure; firm, sticky and plastic; few medium, fine, and very fine roots; common medium and fine pores and many very fine pores; when dry, peds are nearly covered with yellowish-brown, sugarlike coatings; no effervescence with hydrogen peroxide; mildly alkaline.

The A horizon ranges from 7.5YR to 10YR in hue and from 2 to 3 in chroma. The B horizon ranges from 5YR to 10YR in hue, from 3 to 4 in value, and from 2 to 6 in chroma.

This soil is used for sugarcane, pasture, wildlife habitat, and homesites. (Capability classification IVs if irrigated, VIs if nonirrigated; sugarcane group 1; pasture group 5; woodland group 13)

Waikomo very rocky silty clay (Wt).—This soil is similar to Waikomo stony silty clay, except that rock outcrops cover 3 to 25 percent of the surface.

This soil is used for pasture, wildlife habitat, and homesites. Some small areas are irrigated. (Capability classification VIs, irrigated or nonirrigated; pasture group 5; woodland group 13)

Waikomo extremely rocky silty clay (Wu).—This soil is similar to Waikomo stony silty clay, except that rock outcrops cover 25 to 50 percent of the surface.

This soil is used for pasture, wildlife habitat, and homesites. (Capability classification VIIs, nonirrigated; pasture group 5; woodland group 13)

Wailuku Series

This series consists of well-drained soils on alluvial fans on the island of Maui. These soils developed in alluvium derived from weathered basic igneous rock. They are gently to moderately sloping. Elevations range from 50 to 1,000 feet. The annual rainfall amounts to 20 to 40 inches. The mean annual soil temperature is 73° F. Wailuku soils are geographically associated with Iao and Pulehu soils.

These soils are used for sugarcane, pasture, and homesites. The natural vegetation consists of bermudagrass, guineagrass, koa haole, lantana, and Natal redtop.

Wailuku silty clay, 7 to 15 percent slopes (WvC).—This soil is on smooth alluvial fans. Included in mapping were small areas of Iao and Pulehu soils. In a few places moderately steep soils and small, eroded spots were included.

In a representative profile the surface layer is dark reddish-brown silty clay about 12 inches thick. The subsoil, about 48 inches thick, is dark reddish-brown silty clay that has subangular blocky structure. The substratum is gravelly and cobbly alluvium. The soil is slightly acid to medium acid in the surface layer and slightly acid in the subsoil.

Permeability is moderate. Runoff is slow to medium, and the erosion hazard is slight to moderate. The available water capacity is about 1.6 inches per foot in the surface layer and subsoil. In places roots penetrate to a depth of 5 feet or more.

Representative profile: Island of Maui, lat. 20°56′26″ N. and long. 156°31′10″ W.

Ap1—0 to 4 inches, dark reddish-brown (5YR 3/3) silty clay, dark reddish gray (5YR 4/2) when dry; weak, fine and very fine, granular structure; hard, friable, very sticky and very plastic; few roots; many very fine pores; few, fine, black concretions that effervesce with hydrogen peroxide; strong effervescence with hydrogen peroxide; slightly acid; clear, wavy boundary. 2 to 5 inches thick.

Ap2—4 to 12 inches, dark reddish-brown (5YR 3/3) silty clay, reddish brown (5YR 4/3) when dry; weak, medium and fine, subangular blocky structure; hard, firm, very sticky and very plastic; abundant roots; many fine pores; compact in place; few, fine, black concretions; strong effervescence with hydrogen peroxide; medium acid; clear, wavy boundary. 7 to 10 inches thick.

B21—12 to 26 inches, dark reddish-brown (5YR 3/4) silty clay, reddish brown (5YR 4/3) when dry; moderate, medium and fine, subangular blocky structure; slightly hard, friable, very sticky and very plastic; few roots; many fine and very fine pores; continuous pressure cutans; compact in place; few, fine, black concretions; few highly weathered, basic igneous rock pebbles; strong effervescence with hydrogen peroxide; slightly acid; gradual, wavy boundary. 11 to 16 inches thick.

B22—26 to 35 inches, dark reddish-brown (5YR 3/4) silty clay, dark reddish gray (5YR 4/2) when dry; moderate, medium and fine, subangular blocky structure; slightly hard, firm, very sticky and very plastic; few roots; many fine pores; continuous pressure cutans; few, fine, black concretions; few highly weathered basic igneous rock pebbles and cobblestones; strong effervescence with hydrogen peroxide; slightly acid; gradual, wavy boundary. 8 to 12 inches thick.

B3—35 to 60 inches, dark reddish-brown (5YR 3/4) silty clay, reddish gray (5YR 5/2) when dry; moderate, medium to very fine, subangular blocky structure; slightly hard, firm, very sticky and very plastic; few roots; many fine and very fine pores; 10 to 15 percent highly weathered pebbles and cobblestones; strong effervescence with hydrogen peroxide; slightly acid.

The solum is more than 40 inches thick. A few cobblestones and stones are on the surface in some places. The A horizon ranges from 2 to 3 in value when moist and 2 to 4 when dry and from 2 to 3 in chroma when moist or dry. The B horizon ranges from 3 to 5 in value when dry and from 2 to 4 in chroma when moist and 2 to 3 when dry.

This soil is used mostly for sugarcane. A small acreage is used for pasture and homesites. (Capability classification IIIe, irrigated or nonirrigated; sugarcane group 1; pasture group 3; woodland group 1)

Wailuku silty clay, 3 to 7 percent slopes (WvB).—This soil has a profile like that of Wailuku silty clay, 7 to 15 percent slopes, except for the slope. Runoff is slow, and the erosion hazard is slight.

This soil is used for sugarcane and homesites. (Capability classification IIe if irrigated, IIIc if nonirrigated; sugarcane group 1; pasture group 3; woodland group 1)

Wailuku cobbly silty clay, 7 to 15 percent slopes (WwC).—This soil is similar to Wailuku silty clay, 7 to 15 percent slopes, except that it is cobbly in the surface layer. Included in mapping were small areas of nearly level soils and a few areas of moderately steep soils.

This soil is used mostly for sugarcane. A small acreage is used for pasture. (Capability classification IIIe, irrigated or nonirrigated; sugarcane group 1; pasture group 3; woodland group 1)

Wainee Series

This series consists of well-drained soils on alluvial fans on the island of Maui. These soils developed in alluvium derived from weathered basic igneous rock. They are gently to moderately sloping. Elevations range from nearly sea level to 1,000 feet. Rainfall amounts to 10 to 20 inches annually; most of it occurs in winter. The mean annual soil temperature is 75° F. Wainee soils are geographically associated with Pulehu and Wahikuli soils.

These soils are used mostly for sugarcane. A small acreage is used for pasture and homesites. The natural vegetation is fingergrass, kiawe, and uhaloa.

Wainee extremely stony silty clay, 7 to 15 percent slopes (WyC).—This soil is moderately sloping and occurs on smooth, alluvial fans. Included in mapping were small areas of Wahikuli soils.

In a representative profile the surface layer is dark reddish-brown silty clay about 12 inches thick. Stones make up 10 to 15 percent of the volume. The subsoil, 24 inches thick, consists of dark reddish-brown silty clay that has subangular blocky structure. Gravel, cobblestones, and stones make up 30 to 80 percent of the volume. The substratum is dark-brown silty clay. As much as 80 to 90 percent of this layer is gravel, cobblestones, and stones. This soil is neutral in the surface layer and subsoil.

Permeability is moderately rapid. Runoff is slow to medium, and the erosion hazard is slight to moderate. The available water capacity is about 0.6 inch per foot of soil. Stones cover 3 to 15 percent of the surface. Roots penetrate to a depth of 5 feet or more.

Representative profile: Island of Maui, lat. 20°51′26″ N. and long. 156°39′28″ W.

Ap—0 to 12 inches, dark reddish-brown (5YR 3/3) extremely stony silty clay, reddish brown (5YR 4/4) when dry; moderate, fine and very fine, granular structure; slightly hard, friable, sticky and plastic; abundant roots; many fine pores; 10 to 15 percent stones; few highly weathered rock fragments; strong effervescence with hydrogen peroxide; neutral; clear, wavy boundary. 11 to 14 inches thick.

B2—12 to 26 inches, dark reddish-brown (5YR 3/3) extremely stony silty clay, reddish brown (5YR 4/4) when dry; weak, medium and fine, subangular blocky structure; slightly hard, friable, sticky and plastic; plentiful roots; many fine and medium pores; few very fine black specks; moderately firm in place; 30 to 40 percent hard and highly weathered gravel, cobblestones, and stones; strong, delayed effervescence with hydrogen peroxide; neutral; clear, wavy boundary. 12 to 15 inches thick.

B3—26 to 36 inches, dark reddish-brown (5YR 3/3) extremely stony silty clay, reddish brown (5YR 4/4) when dry; weak, medium and fine, subangular blocky structure; slightly hard, friable, sticky and plastic; plentiful roots; many fine pores; few very fine black specks; 70 to 80 percent gray and light yellowish-brown gravel, cobblestones, and stones; strong, delayed effervescence with hydrogen peroxide; neutral; clear, wavy boundary. 9 to 12 inches thick.

IIC—36 to 56 inches, dark-brown (7.5YR 3/2) extremely stony silty clay, dark brown (7.5YR 4/4) when dry; massive; slightly hard, firm, sticky and plastic; few fine and medium pores; 80 to 90 percent gray and light yellowish-brown gravel, cobblestones, and stones; strong effervescence with hydrogen peroxide; slight effervescence with hydrochloric acid on small pebbles; neutral.

Stoniness on the surface ranges from very stony to extremely stony. The texture throughout the profile ranges from silty clay to clay. The content of gravel, cobblestones, and stones in the B horizon ranges from 30 to 80 percent. The A horizon ranges from 2 to 3 in value when moist and from 3 to 4 when dry. The chroma of the A horizon when dry or of the B horizon when moist is 3 to 4. A few of the stones in the C horizon are coated with lime.

This soil is used mostly for sugarcane; a small acreage is used for pasture and homesites. (Capability classification VIs, irrigated or nonirrigated; pasture group 1)

Wainee extremely stony silty clay, 3 to 7 percent slopes (WyB).—On this soil, runoff is slow and the erosion hazard is slight.

This soil is used for sugarcane. (Capability classification VIs, irrigated or nonirrigated; pasture group 1)

Wainee very stony silty clay, 3 to 7 percent slopes (WxB).—On this soil, runoff is slow and the erosion hazard is slight. Stones cover as much as 3 percent of the surface. Included in mapping were small areas where bedrock is at a depth of about 36 inches.

Most of this soil is used for sugarcane; a small acreage is used for homesites. (Capability classification IVs if irrigated, VIs if nonirrigated; sugarcane group 1; pasture group 1)

Wainee very stony silty clay, 7 to 15 percent slopes (WxC).—Stones cover as much as 3 percent of the surface of this soil. Included in mapping were small areas where bedrock is at a depth of about 36 inches. In a few places the slope is moderately steep.

This soil is used mainly for sugarcane; a small acreage is used for homesites. (Capability classification IVs if irrigated, VIs if nonirrigated; sugarcane group 1; pasture group 1)

Waipahu Series

This series consists of well-drained soils on marine terraces on the island of Oahu. These soils developed in old alluvium derived from basic igneous rock. They are nearly level to moderately sloping. Elevations range from nearly sea level to 125 feet. Rainfall amounts to 25 to 35 inches annually; most of it occurs between November and April. The mean annual soil temperature is 75° F. Waipahu soils are geographically associated with Hanalei, Honouliuli, and Waialua soils.

These soils are used for sugarcane and homesites. The natural vegetation is fingergrass, bermudagrass, bristly foxtail, and kiawe.

Waipahu silty clay, 0 to 2 percent slopes (WzA).—This soil is nearly level and occurs on dissected terraces adjacent to the ocean. Included in mapping were small areas of Hanalei, Honouliuli, and Waialua soils. Also included were small areas of clay, where permeability is moderately slow.

In a representative profile the surface layer is dark grayish-brown silty clay about 12 inches thick. The subsoil, about 58 inches thick, is dark-brown silty clay that has prismatic structure. It is very sticky and very plastic in the lower part. The substratum is clayey alluvium. The soil is slightly acid in the surface layer and subsoil.

Permeability is moderately slow. Runoff is slow or very slow, and the erosion hazard is none to slight. The available water capacity is about 1.4 inches per foot in

the surface layer and about 1.6 inches per foot in the subsoil. Roots penetrate to a depth of 5 feet or more.

Representative profile: Island of Oahu, lat. 21°22′58″ N. and long. 158°01′13″ W.

Ap—0 to 12 inches, dark grayish-brown (10YR 4/2) silty clay, dark brown (10YR 4/3) when dry; moderate, fine and very fine, granular structure and moderate, medium, subangular blocky; very hard, friable, sticky and plastic; abundant roots; common, fine and very fine, interstitial pores; few coral fragments; violent effervescence with hydrogen peroxide; slightly acid; clear, smooth boundary. 8 to 12 inches thick.

B21—12 to 26 inches, dark-brown (10YR 4/3) silty clay, dark yellowish brown (10YR 4/4) when dry; strong, very coarse, prismatic structure breaking to moderate, medium and coarse, subangular blocky; hard, firm, sticky and plastic; few coarse roots and abundant very fine roots; few, coarse, tubular pores and common, fine and very fine, tubular pores; many weak pressure faces; few coatings in pores; few, fine, black concretions; strong effervescence with hydrogen peroxide; slightly acid; gradual, wavy boundary. 10 to 14 inches thick.

B22—26 to 36 inches, dark-brown (10YR 4/3) silty clay, dark yellowish brown (10YR 4/4) when dry; strong, very coarse, prismatic structure breaking to moderate, medium and coarse, subangular and angular blocky; hard, firm, sticky and plastic; few coarse roots and plentiful very fine roots; few, coarse tubular pores and common, fine and very fine, tubular pores; common pressure faces on peds, thin coatings in pores; few, fine, black concretions; strong effervescence with hydrogen peroxide; slightly acid; gradual, smooth boundary. 8 to 12 inches thick.

B23—36 to 46 inches, dark-brown (10YR 4/3) silty clay, dark yellowish brown (10YR 4/4) when dry; strong, coarse, prismatic structure breaking to moderate, medium and coarse, subangular and angular blocky; hard, firm, sticky and plastic; few coarse roots and plentiful fine roots, mainly matted between prisms; few, coarse, tubular pores and many, very fine, tubular pores; black stains in pores and on ped faces; common pressure faces on peds; common, deeply grooved slickensides, oriented at 20 degrees; strong effervescence with hydrogen peroxide; slightly acid; gradual, smooth boundary. 8 to 12 inches thick.

B24—46 to 70 inches, dark-brown (10YR 4/3) silty clay, dark yellowish brown (10YR 4/4) when dry; strong, coarse, prismatic structure breaking to strong, medium and coarse, subangular blocky; very hard, firm, very sticky and very plastic; few fine roots; many very fine pores; coatings in pores; common pressure faces; many, fine, black concretions; prominent black stains; common, deeply grooved slickensides; strong effervescence with hydrogen peroxide; slightly acid.

The solum ranges from 10YR to 7.5YR in hue. The A and B horizons range from 2 to 4 in value when moist. The B horizon ranges from 4 to 5 in value when dry. The A and B horizons range from 2 to 3 in chroma when moist and from 3 to 5 when dry.

This soil is used for sugarcane and homesites. (Capability classification I if irrigated, IVc if nonirrigated; sugarcane group 1; pasture group 3)

Waipahu silty clay, 2 to 6 percent slopes (WzB).—On this soil, runoff is slow and the erosion hazard is slight.

This soil is used for sugarcane and homesites. (Capability classification IIe if irrigated, IVc if nonirrigated; sugarcane group 1; pasture group 3)

Waipahu silty clay, 6 to 12 percent slopes (WzC).—On this soil, runoff is medium and the erosion hazard is moderate. Included in mapping were small gravelly areas where the slope is as much as 20 percent. Also included was a small area of clay where the slope is 12 to 15 percent.

This soil is used for sugarcane and homesites. (Capability classification IIIe if irrigated, IVe if nonirrigated; sugarcane group 1; pasture group 3)

Use and Management of the Soils

The soils of the Hawaiian Islands are used for sugarcane, pineapple, pasture, woodland, truck crops, orchards, and wildlife. This section describes the limitations and management needs of the soils for each of these uses. It explains the land capability groupings used by the Soil Conservation Service and also discusses soil properties that are significant in engineering.

Sugarcane Management

Sugarcane is grown on the islands of Kauai, Maui, and Oahu. It is not grown on Molokai and Lanai because the supply of irrigation water is inadequate.

Sugarcane is harvested about every 20 to 24 months. The age that the cane is harvested depends to a large extent on the variety of cane and the climate. The harvesting is not necessarily followed by the planting of a new crop. After harvest, the cane root system sends up new sprouts or shoots of the next crop. Replanting is needed only in introducing new varieties, altering the irrigation or field layout, reducing compaction of the soil, or repairing field damage caused by harvesting. Cultural practices vary according to the nature of the soil and the climatic conditions.

If a new planting of sugarcane is to be established, the fields are smoothed and subsoiled or disk plowed and harrowed. If the field is to be irrigated, the irrigation, drainage, and road systems are installed. Terraces, diversions, grassed waterways, and roads are installed in nonirrigated areas. Then the seed stalk is planted, by machine or by hand, in the bottom of a machine-opened furrow and covered with a few inches of soil. Furrows near the contour facilitate irrigation and minimize erosion. After harvest, the furrows, terraces, diversions, roads, and waterways are reshaped and the ditches are repaired.

Fertilizer is applied by hand, machine, or airplane, or by the use of soluble forms of fertilizer in the irrigation water. Lime is needed on some soils. Nitrogen, phosphorus, and potassium are used in the amounts indicated by soil tests, tissue analysis, field trials, and experience.

Herbicides and hand weeding are used to control weeds.

Erosion control, fertilizer, and irrigation in the drier areas are needed to protect the soil and produce good growth.

The sugarcane industry is highly mechanized. The use of heavy equipment permits the production of sugarcane on some extremely stony soils that otherwise would be considered unsuited to cultivation.

The present method of harvesting sugarcane consists of burning the canefields to remove excess leaves. Immediately after burning, a machine-mounted push rake pushes the cane stalks into piles. Large track-type cranes

load the stalks into trucks that transport the cane to the mill. These operations cause soil disturbance and increase the erosion hazard. Harvesting during periods of low rainfall reduce soil and water losses. The harvest schedule should provide time for regrowth so that the soil is protected during periods of high rainfall. The hazard of erosion can be reduced by establishing grassed waterways, irrigating and planting on the contour, lining ditches and canals, and using diversion ditches in the fields.

Sugarcane groups

The soils of the islands are grouped according to their suitability for sugarcane. The grouping is based on the similarity of management needs, including irrigation, and the amounts of solar insolation. There are four groups. Each group is described in the following pages, and suggestions for management are given.

The names of the soil series represented are listed in the description of each group, but this does not mean that all the soil mapping units of a given series are in the group. The designated group for each soil can be found in the "Guide to Mapping Units."

SUGARCANE GROUP 1

This group consists of excessively drained to well-drained soils of the following series:

Alae	Koloa	Pakala
Ewa	Kunia	Pohakupu
Haleiwa	Lahaina	Puhi
Haliimaile	Lihue	Pulehu
Iao	Mahana	Wahiawa
Ioleau	Makaweli	Wahikuli
Jaucas	Mamala	Waiakoa
Kawaihapai	Manana	Waikomo
Keahua	Mokuleia	Wailuku
Kekaha	Molokai	Wainee
Kemoo	Niu	Waipahu
Kolekole	Paia	

These soils are sands, loams, silt loams, clay loams, silty clay loams, silty clays, and clays. They occur in areas where insolation is high. The slope ranges from 0 to 25 percent. Average annual rainfall amounts to 12 to 80 inches. The mean annual soil temperature is between 60° and 75° F.

Permeability is moderate to rapid. Runoff is very slow to medium, and the erosion hazard is slight to moderate. From 0.5 inch to 2.2 inches of water is available per foot of soil. The rooting depth is 15 to 60 inches or more.

These soils are irrigated by sprinklers (fig. 9) or by furrows from ditches or aluminum and concrete flumes. Furrows are laid out across the slope near the contour. Their gradient is 0.5 to 1.5 percent. All planting and tilling are done across the slope near the contour. Secondary field roads crosswise of the slope serve as diversions.

Yields are 12 to 15 tons per acre per crop.

SUGARCANE GROUP 2

This group consists of moderately well drained and well drained soils of the Halii, Hanamaulu, Kalapa, Kapaa, Lawai, Leilehua, Paaloa, and Pooku series. These soils are silty clay loams, silty clays, and clays. They occur in areas where solar insolation is relatively low. The slope ranges from 0 to 25 percent. Rainfall is well distributed throughout the year. The average annual amount is 50 to 150 inches for all except Halii and Hanamaulu soils, which receive 200 to 250 inches. The mean annual soil temperature is between 69° and 74° F.

Figure 9.—Irrigation of sugarcane by high-volume gun sprinkler.

Permeability is moderate to moderately rapid. Runoff is very slow to medium, and the erosion hazard is slight to moderate. About 1 or 2 inches of water is available per foot of soil. The rooting depth is 24 to 60 inches or more.

These soils are generally not irrigated. Young cane should be alternated with old cane in strips. The width of the strips is determined by the kind of soil, the length and gradient of the slope, and the intensity and frequency of rainfall. All planting and tilling should be done across the slope near the contour. Secondary roads crosswise of the slope serve as diversions.

Yields are 8 to 10 tons per acre per crop.

SUGARCANE GROUP 3

This group consists of very poorly drained and poorly drained soils of the Hanalei, Kaena, Kalihi, Kaloko, Keaau, Mokuleia, and Nohili series. These soils are silty clay loams, silty clays, and clays. They occur in areas where solar insolation is high. The slope ranges from 0 to 25 percent. The average annual rainfall is 20 to 60 inches for all except Hanalei soils, which receive 120 inches. The rooting depth is 20 to 60 inches.

Permeability is very slow to moderately rapid. Runoff is very slow to medium, and the erosion hazard is slight to moderate. About 1.4 to 2.1 inches of water is available per foot of soil.

These soils are irrigated by furrows generally from ditches constructed across the slope near the contour. Aluminum and concrete flumes are used if the slope is more than 1.5 percent. Cutoff drains and drainage ditches reduce seepage and help in controlling the height of the water table. Streambank stabilization and suitable outlets minimize flood damage.

Yields are 9 to 12 tons per acre per crop.

SUGARCANE GROUP 4

This group consists of moderately well drained and well drained soils of the Honouliuli, Kaena, Lualualei, Makalapa, Nonopahu, and Waialua series. These soils are silty clays and clays. They occur in areas where solar insolation is high. They are sticky and very plastic and can be cultivated within only a narrow range of moisture content. The slope ranges from 0 to 25 percent. The average annual rainfall is 18 to 50 inches. The mean annual soil temperature is between 72° and 75° F.

Permeability is slow to moderate. Runoff is slow to medium, and the erosion hazard is slight to moderate. About 1.3 to 2 inches of water is available per foot of soil. The rooting depth is 20 to 60 inches or more.

These soils are irrigated by furrows from ditches or from aluminum and concrete flumes. The furrows are laid out across the slope near the contour. Their gradient is 0.5 to 1.5 percent. Secondary field roads crosswise of the slope serve as diversions. All harvesting is done during dry periods.

Yields are 12 to 15 tons per acre per crop.

Pineapple Management

Pineapple, which is grown on all the islands in this survey area, is the second most important farm crop in Hawaii. It grows best in well-drained, nonstony soils in areas where solar insolation is high.

Pineapple is grown in a cycle that extends over a period of about 40 months. The cycle extends from the time the crop is planted until the same soil is again prepared and planted. Two crops of pineapple are commonly harvested from each cycle. The first crop, or the plant crop, matures in 16 to 24 months, depending on the kind of planting material and the weather conditions. The second crop, or the ratoon crop, matures a year later.

Cultural practices for growing pineapple vary from one plantation to the next. Seedbed preparation begins with the removal of the old pineapple plants. The plants are removed either by a clean tillage method in which the plants are chopped and plowed under, or by a method in which the plants are chopped and the crop residue is left on the surface as a mulch. In the first method the soil is plowed and disked several times, whereas in the second method little tillage is done. In order to reduce the amount of residue the plants are sometimes partially burned after they are chopped.

A few days before planting, a machine, in one operation, applies a soil fumigant and fertilizer, forms a planting bed, and covers it with a strip of polyethylene. The polyethylene serves as a mulch and reduces soil losses, controls weeds, and forms a seal for the soil fumigants. Slips, suckers, or crowns are planted by hand through the polyethylene strips.

Fertilizer is applied in the soil before planting and as a foliar spray as needed. Plants respond well to nitrogen, phosphorus, and potassium. Iron is needed on all soils, and zinc and lime are needed on some. The kind and amount of fertilizer needed are determined by soil tests, tissue analysis, field trials, and experience.

Pineapple fields are divided into blocks 100 to 130 feet wide. The blocks are of uniform width and are separated by roads used by spraying and harvesting machines. The machines have arms that extend to half the width of the blocks. Hormones that control fruiting time, insecticides, and herbicides are applied.

Pineapple groups

The soils of the islands are grouped according to their suitability for pineapple. The grouping is based on the similarity of management needs, the slope, the amount of solar insolation, and the amount of rainfall. There are eight groups. Each group is described in the following pages, and suggestions for management are given.

The names of the soil series represented are listed in the description of each group, but this does not mean that all the soil mapping units of a given series are in the group. The designated group for each soil can be found in the "Guide to Mapping Units."

PINEAPPLE GROUP 1

This group consists of well drained or moderately well drained soils of the Ewa, Holomua, Hoolehua, Kunia, Lahaina, Molokai, Waihuna, and Waikapu series. These soils are dominantly silt loams, silty clay loams, and silty clays. They occur in areas where insolation is high. The slope ranges from 0 to 3 percent. In most places the elevation is less than 1,000 feet, but it ranges from near sea level to 2,000 feet. The annual rainfall is 10 to 40 inches.

Permeability is moderately slow to moderately rapid. Runoff is very slow to slow, and the erosion hazard is

slight. About 1 or 2 inches of water is available per foot of soil. The rooting depth is 40 to 60 inches or more.

All planting and tilling are done across the slope. Grassed waterways are needed in some areas. In most places a mulch of crop residue (fig. 10) is beneficial, but a mulch should not be used at elevations of more than 1,000 feet, because above this level the environment is favorable for the growth of organisms that cause plant diseases. At the lower elevations mulching not only conserves moisture and controls weeds but also protects the soil from erosion.

If a mulch is used, pineapple can be grown without irrigation in areas where the annual rainfall is less than 25 inches. In these areas, planting is scheduled to take advantage of the rainy season.

If irrigation water is available, areas that receive less than 25 inches of rainfall annually are usually irrigated by truck-mounted sprinklers or giant sprinklers (fig. 11). An inch of water is applied at each irrigation, usually in summer, or as needed soon after planting. Irrigation insures uniform establishment of plants.

Yields amount to 35 to 45 tons per acre for the plant crop and 25 to 35 tons per acre for the ratoon crop.

PINEAPPLE GROUP 2

This group consists of well-drained soils of the following series:

Ewa
Holomua
Hoolehua
Keahua
Koele
Kunia
Lahaina
Molokai
Uwala
Waihuna
Waikapu

These soils are dominantly silt loams, silty clay loams, and silty clays. They occur in areas where solar insolation is high. The slope ranges from 3 to 8 percent. The elevation ranges from near sea level to 2,000 feet but is generally less than 1,000 feet. The average annual rainfall is 15 to 40 inches.

Permeability is moderately slow to moderately rapid. Runoff is slow to medium, and the erosion hazard is slight. About 1 or 2 inches of water is available per foot of soil. The rooting depth is 40 to 60 inches or more.

All planting and tilling are done across the slope. Field roads serve as diversions. Grassed waterways are needed in some areas. A mulch of crop residue is beneficial except at elevations of more than 1,000 feet. At the lower elevations mulching conserves moisture, controls weeds, and reduces the hazard of erosion, but at the higher elevations it increases the growth of organisms that cause plant diseases.

If a mulch is used, pineapple can be grown without irrigation in areas where the annual rainfall is less than 25 inches. In these areas, planting is scheduled to take advantage of the rainy season.

Figure 10.—Young pineapple plants mulched with crop residue. The soil is a Holomua silt loam.

Figure 11.—**Pineapple irrigated by giant sprinklers.**

If irrigation water is available, areas that receive less than 25 inches of annual rainfall are usually irrigated by truck-mounted sprinklers or giant sprinklers. An inch of water is applied at each application, usually in summer, or as needed soon after planting. Irrigation insures uniform establishment of plants.

Yields are 35 to 45 tons per acre for the plant crop and 25 to 35 tons per acre for the ratoon crop.

PINEAPPLE GROUP 3

This group consists of well-drained soils of the following series:

Ewa	Kunia
Holomua	Lahaina
Honolua	Molokai
Hoolehua	Uwala
Keahua	Waihuna
Koele	Waikapu

These soils are dominantly silt loams, silty clay loams, and silty clays. They occur in areas where solar insolation is high. The slope ranges from 8 to 25 percent. The elevation ranges from near sea level to 2,000 feet but is generally less than 1,000 feet. The average annual rainfall is 15 to 40 inches.

All planting and tilling are done across the slope or on the contour (fig. 12). Workability is slightly difficult because of the slope. Diversion ditches on a graded contour carry runoff water from the fields. Grassed waterways and outlets are needed. A mulch of crop residue conserves moisture, controls weeds, and reduces the hazard of erosion. In areas where the elevation is more than 1,000 feet, mulching increases heart rot and root rot diseases.

If a mulch is used, pineapple can be grown without irrigation in areas where the annual rainfall is less than 25 inches. In these areas, planting is scheduled to take advantage of the rainy season.

If irrigation water is available, areas that receive less than 25 inches of annual rainfall are usually irrigated by truck-mounted sprinklers or stationary sprinklers. An inch of water is applied at each application, usually in summer, or as needed soon after planting. Irrigation insures uniform establishment of plants.

Yields are 35 to 45 tons per acre for the plant crop and 25 to 35 tons per acre for the ratoon crop.

PINEAPPLE GROUP 4

This group consists of well-drained soils of the Puhi and Wahiawa series. These soils are silty clays and silty

Figure 12.—Erosion controlled by planting pineapple on the contour. Infield roads serve as diversions during intense storms.

clay loams. They occur in areas where solar insolation is moderate to high. The slope ranges from 0 to 3 percent. The elevation ranges from near sea level to 1,200 feet. The average annual rainfall is 40 to 70 inches.

Permeability is moderately rapid. Runoff is very slow to slow, and the erosion hazard is slight. About 1 to 2 inches of water is available per foot of soil. The rooting depth is 20 to 60 inches or more.

All planting and tilling are done across the slope. Grassed waterways are needed in some areas. Rainfall is ample; no irrigation is needed. In nearly all areas the old plants are plowed under. Crop-residue mulch is not used because it increases heart rot and root rot diseases.

Yields are 35 to 45 tons per acre for the plant crop and 25 to 35 tons per acre for the ratoon crop.

PINEAPPLE GROUP 5

This group consists of well-drained soils of the following series:

Alaeloa
Haiku
Haliimaile
Hamakuapoko
Ioleau
Kahana
Kalae
Kemoo
Kolekole
Leilehua
Lihue
Makawao
Manana
Puhi
Wahiawa

These soils are dominantly clays, silty clays, and silty clay loams. They occur in areas where solar insolation is moderate to high. The slope ranges from 3 to 8 percent. The elevation ranges from near sea level to 2,200 feet. The average annual rainfall is 40 to 70 inches.

Permeability is slow to moderately rapid. Runoff is slow, and the erosion hazard is slight to moderate. About 1 to 2 inches of water is available per foot of soil. The rooting depth is 20 to 60 inches or more.

All planting and tilling are done across the slope or on the contour. Field roads serve as diversions. Grassed waterways are needed in some areas. Rainfall is ample; no irrigation is needed. In nearly all areas the old plants are plowed under. Crop residue mulch is not used because it increases heart rot and root rot diseases.

Yields are 35 to 45 tons per acre for the plant crop and 25 to 35 tons per acre for the ratoon crop.

PINEAPPLE GROUP 6

This group consists of well-drained soils of the following series:

Alaeloa	Kolekole
Haiku	Leilehua
Haliimaile	Lihue
Hamakuapoko	Mahana
Ioleau	Makawao
Kahana	Manana
Kalae	Puhi
Kemoo	Wahiawa

These soils are dominantly clays, silty clays, and silty clay loams. They occur in areas where solar insolation is moderate to high. The slope ranges from 8 to 25 percent. The elevation ranges from near sea level to 2,200 feet. The average annual rainfall is 40 to 70 inches.

Permeability is slow to moderately rapid. Runoff is slow to medium, and the erosion hazard is slight to moderate. About 1 to 2 inches of water is available per foot of soil. The rooting depth is 20 to 60 inches or more.

All planting and tilling are done across the slope or on the contour. Workability is slightly difficult because of the slope. Diversion ditches on a graded contour carry runoff water from the fields. Waterways and outlets are grassed. No irrigation is needed. In nearly all areas the old plants are plowed under. Crop residue mulch is not used because it increases heart rot and root rot diseases.

Yields are 35 to 45 tons per acre for the plant crop and 25 to 35 tons per acre for the ratoon crop.

PINEAPPLE GROUP 7

This group consists of moderately well drained to well drained soils of the Halii, Kapaa, and Pauwela series. These soils are dominantly silty clay loams, silty clays, and clays. They occur in areas where solar insolation is low. The slope ranges from 3 to 8 percent. The elevation ranges from 100 to 1,500 feet. The average annual rainfall is 70 to 120 inches.

Permeability is moderately rapid. Runoff is slow to medium, and the erosion hazard is slight. About 1 to 2 inches of water is available per foot of soil. The rooting depth is 30 to 60 inches or more.

All planting and tilling are done across the slope or on the contour. Field roads serve as diversions. Grassed waterways are needed in some areas. Rainfall is ample; no irrigation is needed. In nearly all areas the old plants are plowed under. Crop residue mulch is not used because it increases heart rot and root rot diseases.

Yields are 30 to 40 tons per acre for the plant crop and 20 to 30 tons per acre for the ratoon crop.

PINEAPPLE GROUP 8

This group consists of moderately well drained to well drained soils of the Halii, Kapaa, and Pauwela series. These soils are dominantly silty clay loams, silty clays, and clays. They occur in areas where insolation is low. The slope ranges from 8 to 25 percent. The elevation ranges from 100 to 1,500 feet. The average annual rainfall is 70 to 120 inches.

Permeability is moderately rapid. Runoff is slow to medium, and the erosion hazard is slight to severe. About 1 to 2 inches of water is available per foot of soil. The rooting depth is 30 to more than 60 inches.

All planting and tilling are done across the slope or on the contour. Workability is impaired somewhat by the slope. Diversion ditches on a graded contour carry runoff from the fields. No irrigation is needed. Waterways and outlets are grassed. In nearly all areas the old plants are plowed under. Crop residue is not used on the soils in this group, because mulching increases heart rot and root rot diseases.

Yields are 30 to 40 tons per acre for the plant crop and 20 to 30 tons per acre for the ratoon crop.

Pasture Management [2]

Approximately 385,000 acres in this survey area is used for cattle grazing. Ranches range in size from 66,000 acres to small units operated by part-time ranchers. Nearly all ranches are the cow-calf type. Beef animals are generally marketed as yearlings; some weaners are sold as feeders.

The native vegetation of the Hawaiian Islands quickly disappeared after the introduction of cattle. All of the present improved forage species have been introduced from other areas of the world.

Forage production in areas of low rainfall is extremely variable from year to year. In seasons of adequate rainfall, the green-feed period extends from November to July. In seasons of low rainfall the period is much shorter. During droughts, green forage is generally nonexistent. In areas of heavier rainfall forage production is more consistent from year to year.

Establishment of pasture

A prepared seedbed insures a good stand of the seeded species and is essential for the establishment of pasture. In areas where it is impractical to prepare a seedbed by cultivation, other practices, such as chain dragging, brush rake dozing, controlled burning, and chemicals, can be used to control the existing vegetation.

An application of nitrogen or nitrogen-phosphorus fertilizer is generally needed for the establishment of grasses. A phosphorus or phosphorus-lime fertilizer is generally needed for the successful establishment of grass-legume pasture. Periodic applications of fertilizer are needed for good pasture production and maintenance. The rate of application and the timing depend on the pasture species, the soil, the climatic condition, and the season of use.

Using the best planting stock available, that is, clean seed that has a high germination percentage, helps insure a good stand. Inoculating legumes with the proper Rhizobium species is essential for the establishment of a stand, for maximum forage yields, and for sustained production. Weeds can be controlled with chemicals, by clipping or mowing, or by controlled grazing.

Improved grasses and legumes suited to the survey area are described in the following paragraphs.

KOA HAOLE (*Leucaena leucocephaia*).—This is a deep-rooted, leguminous, long-lived shrub or small tree. It is suited to areas that have 25 to 60 inches of annual rainfall and elevations up to 1,500 feet.

Koa haole is established from seed. For best results it should be mechanically planted in a prepared seedbed, with either guineagrass or green panicgrass, and managed to fit the growth cycle of the companion grass.

[2] D. N. PALMER AND T. A. BOWN, plant materials specialists, SCS, assisted in the preparation of this section.

BIG TREFOIL (*Lotus uliginosus*).—This is a long-lived, semiprostrate legume that has rhizomes and a large fibrous root system. It is suited to areas that have more than 60 inches of annual rainfall and elevations of more than 1,000 feet. It grows in open sunlight or partial shade.

This legume is established from seed or cuttings and is planted with either kikuyugrass or pangolagrass. It has a 30-day regrowth cycle during the warmest months and a 45-day regrowth cycle during the coldest months. It withstands close grazing, that is, as close as 2 inches, on a rotational basis.

INTORTUM (*Desmodium intortum*).—This is a long-lived legume that has a long decumbent stem. It is suited to areas that have 60 to 120 inches of annual rainfall and elevations up to 3,000 feet.

Intortum is established from either seed or cuttings. For best results seeds should be mechanically planted in rows on a prepared seedbed. This legume is generally planted with pangolagrass, and the two are managed for the intortum. After the leaves have been stripped from the stems, grazing should be deferred and the intortum allowed to regrow. The regrowth cycle is about 60 days in summer and 90 days in winter.

BUFFELGRASS (*Cenchrus ciliaris*).—This is a long-lived bunchgrass. It is well suited to areas that have 10 to 40 inches of annual rainfall and elevations of less than 2,000 feet. It has a high potential for forage production and a large fibrous root system that helps control erosion.

Buffelgrass is readily established from seed. It is best established by shallow seeding with a mechanical planter on a prepared seedbed. A rotational system of deferred grazing that provides a seed crop improves thin stands and helps in maintaining the pasture. After a significant rain, the pasture can be grazed within 21 to 30 days. If enough soil moisture is available, buffelgrass is grazed on a 30-day rotation. It should never be grazed closer than 2 to 3 inches.

GREEN PANICGRASS (*Panicum maximum* var. *tricoglume*).—This is a long-lived bunchgrass 3 to 6 feet tall. It is suited to areas that have 22 to 60 inches of annual rainfall and elevations of less than 2,000 feet. It is a high-producing forage plant that makes good ground cover and helps control erosion.

Green panicgrass is easily established from seed. It has excellent seedling vigor. For best results it should be mechanically planted on a prepared seedbed. The stands can be improved and forage can be provided during the dry season by a system of deferred grazing that produces a seed crop. Established pasture of green panicgrass can be grazed 30 to 40 days after the end of the dry season. It has a 30-day regrowth cycle during the warm months and a 45-day regrowth cycle during the cool months. For best results, green panicgrass should not be grazed closer than 4 to 6 inches.

GUINEAGRASS (*Panicum maximum*).—This is a long-lived bunchgrass 6 to 8 feet tall. It is suited to areas that have 25 to 60 inches of annual rainfall and elevations of less than 2,000 feet. It has a high potential for forage production. The large fibrous root system is a good soil binder and helps control erosion.

Guineagrass is easily established from seed on a prepared seedbed. Thin stands can be improved by a system of deferred grazing that provides a seed crop. An established guineagrass pasture can be grazed 40 to 60 days after the end of the dry season. If soil moisture is sufficient, guineagrass can be grazed on a 60-day cycle during the hot months and a 90-day cycle during the cool months. To maintain good production and a good stand, this grass should not be grazed closer than 8 to 10 inches.

KIKUYUGRASS (*Pennisetum clandestinum*).—This is a long-lived, deep-rooted, sod-forming grass that spreads by stolons and forms a dense turf. It is an excellent pasture and soil-stabilizing grass. It is suited to all elevations where annual rainfall is 40 to 80 inches.

Kikuyugrass is established from sprigs. It has a 30-day regrowth cycle during the warmest months, and a 45-day regrowth cycle during the coolest months. For best results it should not be grazed closer than 2 inches.

PANGOLAGRASS (*Digitaria decumbens*).—This is a long-lived grass 2 to 3 feet tall. It has long stolons that root at the nodes and an open turf. It produces good forage and provides excellent ground cover that helps control erosion. It is suited to areas that have 60 to 120 inches of annual rainfall and elevations of less than 3,000 feet.

Pangolagrass does not produce viable seed. It is propagated by sprigging. For best results the sprigs should be planted less than 2 inches deep in a prepared seedbed. Established pangolagrass has a regrowth cycle of 30 days during the warm months and 45 days during the cool months.

CALIFORNIAGRASS (*Brachiaria mutica* syn. *Panicum purpurascens*).—This is a long-lived, sod-forming grass. It has a coarse trailing stem that roots at the nodes. The flower stem is as much as 6 feet tall. Californiagrass, also commonly called paragrass, has a high potential for forage production. It is particularly suited to poorly drained soils that are less than 2,000 feet in elevation. Californiagrass is a poor seed producer and is usually propagated from cuttings, or sprigs. Established paragrass has a regrowth cycle of 60 days during the warm months and 90 days during the cool months. Locally, it is used mainly as green-chop forage.

Forage production

The consistent variation in forage production from season to season, the lengths of the green-feed period, and a balance between the number of stock and the amount of forage are all factors to be considered in planning pasture management. Pasture rotation, periodic deferment, and a good fertilization program help in maintaining the desirable forage plants. Extreme care in grazing newly seeded pastures prevents the destruction of the new seedlings. During the first year it is desirable to allow bunchgrasses to produce a seed crop to insure a good stand.

Continuous grazing lowers forage yields, weakens the vigor of the forage plants, and reduces their ability to compete with other plants. Rotational grazing of pasture improves the utilization and production of forage, reduces weeds, and prolongs the life of the plantings (fig. 13).

Most pastures eventually need reseeding. The productive life of the forage plant depends on the species and the kind of management.

Figure 13.—Rotation grazing on fertilized pangolagrass-kaimi clover pasture.

Pasture groups

The soils of the islands are grouped according to their suitability for pasture. In each group are soils that produce about the same kinds and amounts of vegetation and require similar management. There are 14 groups, 13 of which consist of soils and 1 of land types. Each is described in the following pages. Also, the species suitable for each group are named and the estimated potential productivity is given.

The names of the soil series represented are mentioned in the description of each group, but this does not mean that all the soil mapping units of a given series are in the group. The designated group for each soil can be found in the "Guide to Mapping Units." No designations are given in the guide for the miscellaneous land types mapped in the reconnaissance survey. All are in pasture group 14.

PASTURE GROUP 1

This group consists of soils of the following series:

Alae	Makena
Holomua	Mala
Jaucas	Puuone
Kapuhikani	Waiakoa
Kealia	Wainee
Keawakapu	

These soils are on alluvial fans, terraces, and low uplands in the drier parts of the survey area. They developed in material weathered from basic igneous rocks and in alluvium, coral sand, and volcanic ash. They are 20 to more than 60 inches deep. The slope range is 0 to 15 percent. The elevation ranges from sea level to 1,500 feet. In most places average annual rainfall amounts to 10 to 20 inches annually. The mean annual air temperature is between 73° and 78° F. This pasture group makes up about 66,500 acres.

Drainage is good, except in areas of Kealia soils. Permeability is rapid to moderate in all except Kapuhikani soils, where it is moderately slow to slow.

The vegetation in unimproved pasture is dominantly piligrass, white piligrass, feather fingergrass, ilima, uhaloa, Japanese tea, golden crownbeard, and zinnia. Kiawe trees grow in dense stands along the coastal flats and in open stands on the uplands. In summer the main source of forage along the coastal flats is kiawe pods. Pickleweed is the dominant plant on Kealia soils. Unimproved pasture produces 400 to 1,300 pounds of air-dry forage per acre per year. Three-fourths or more of the annual forage crop is produced during the rainy season. In summer, most of the annuals die and the perennials become dormant.

Forage species for improved pasture are buffelgrass, white piligrass, and giant bermudagrass. Buffelgrass is especially well suited; it spreads rapidly and provides ground cover for eroded areas. Guineagrass and koa haole are suitable in areas where rainfall is more plentiful and in areas along the coast where ground water is

near the surface. Australian saltbush is the only improved species suitable for the saline Kealia soils. Well-managed improved pasture produces 1,700 to 2,600 pounds of air-dry forage per acre per year.

Improvement of pasture is difficult in stony areas. Seeding, fertilization, and weed and brush control are limited to hand and aerial methods. Improvement of pasture on eroded soils is difficult because of strong winds and low rainfall.

PASTURE GROUP 2

This group consists of soils of the following series:

Ewa	Nonopahu
Honouliuli	Oanapuka
Keahua	Pakala
Kekaha	Pulehu
Koko	Puu Pa
Lualualei	Uwala
Makaweli	Waikapu
Mamala	Waiawa
Molokai	

These soils are on alluvial fans, terraces, and low uplands. They developed in alluvium, marine sediments, volcanic ash, and material weathered from basic igneous rocks. Mamala and Waiawa soils are less than 20 inches deep; the rest are 20 to more than 60 inches deep. Slopes are dominantly 0 to 35 percent but range from 50 to 80 percent on Waiawa soils. The elevation is less than 1,000 feet in most places but ranges to 2,500 feet in areas of Puu Pa and Waiawa soils. The average annual rainfall is mainly 15 to 35 inches. The mean annual air temperature is between 70° and 75° F. This pasture group makes up about 157,000 acres.

Drainage is good to moderately good. Permeability is moderately rapid to slow.

The vegetation in unimproved pasture is dominantly kiawe, koa haole, klu, ilima, uhaloa, lantana, buffelgrass, bermudagrass, piligrass, fingergrass, and bristly foxtail. Forage production in winter is estimated to be approximately three times as much as that in summer. Total production is 700 to 1,700 pounds of air-dry forage per acre per year.

Buffelgrass, white piligrass, giant bermudagrass, guineagrass, and koa haole are suitable species for improved pasture. Well-managed improved pasture produces 1,400 to 2,600 pounds of air-dry forage per acre per year.

Improvement of pasture is difficult on extremely stony and extremely rocky soils and on soils steeper than 40 percent. Seeding, fertilization, and weed and brush control are limited to hand and aerial methods. Improvement is difficult on eroded soils because of strong winds and low rainfall. It is difficult on Lualualei soils because these soils are very sticky and very plastic and have poor workability.

PASTURE GROUP 3

This group consists of soils of the following series:

Haleiwa	Kahana
Haliimaile	Kamaole
Helemano	Kanepuu
Hoolehua	Kaupo
Iao	Kawaihapai
Koele	Pamoa
Kokokahi	Papaa
Kunia	Wahikuli
Lahaina	Waialua
Makalapa	Waihuna
Mokuleia	Wailuku
Niu	Waipahu
Paia	

These soils are on coastal plains, alluvial fans, terraces, and low uplands. They developed in alluvium, volcanic ash, and material weathered from basic igneous rocks. They are 20 to more than 60 inches deep. Slopes are dominantly 0 to 35 percent but are more than 35 percent on Helemano and Papaa soils. The elevation ranges from near sea level to about 2,000 feet. The average annual rainfall is mainly 25 to 40 inches but ranges from 20 to 60 inches. The mean annual temperature is between 69° and 75° F. This pasture group makes up about 151,700 acres.

Drainage is good to moderately good except on the Mokuleia poorly drained variant. Permeability is moderately rapid to slow.

The vegetation in unimproved pasture is dominantly kiawe, koa haole, klu, lantana, molassesgrass, bermudagrass, dallisgrass, Natal redtop, uhaloa, ilima, sourgrass, piligrass, and fuzzy top. Guava and Christmas berry grow in the areas of heaviest rainfall. Forage production in winter is estimated to be about three times as much as that in summer. Total production is 1,000 to 2,000 pounds of air-dry forage per acre per year.

Buffelgrass, guineagrass, green panicgrass, and koa haole are suitable species for improved pasture. Well-managed improved pasture produces 2,000 to 4,800 pounds of air-dry forage per acre per year.

PASTURE GROUP 4

This group consists of soils of the Kula, Io, and Uma series. These soils are on low and intermediate uplands. They developed in volcanic ash and cinders. Kula soils are 24 to more than 60 inches deep over bedrock. Io soils are 20 to 40 inches deep over fine cinders. Uma soils are less than 10 inches deep over fine cinders. The slope range is dominantly 0 to 40 percent but is as much as 70 percent for Uma soils. The elevation is dominantly 1,000 to 4,000 feet but ranges to 6,000 feet for Uma soils. The average annual rainfall is 25 to 40 inches. The mean annual air temperature is between 56° and 69° F. This pasture group makes up 17,450 acres.

Drainage is good to excessive. Permeability is very rapid to moderately rapid.

The vegetation in unimproved pasture is dominantly bermudagrass, rattailgrass, yellow foxtail, Natal redtop, black wattle, and joee. Forage production in winter is about twice as much as that in summer. Total production of unimproved pasture is 2,000 to 3,000 pounds of air-dry forage per acre per year.

Guineagrass, green panicgrass, kikuyugrass, and Glycine are suitable species for improved pasture. Well-managed improved pasture produces 3,500 to 6,000 pounds of air-dry forage per acre per year.

PASTURE GROUP 5

This group consists of soils of the Kaimu, Kalaupapa, Kemoo, Koloa, Lihue, Pane, Ulupalakua, Wahiawa, and Waikomo series. These soils are on uplands. They developed in volcanic ash and material weathered from basic igneous rocks. The slope range is up to 70 percent for Kemoo soils but is 0 to 40 percent for the rest. The elevation ranges from near sea level to 4,500 feet. The average annual rainfall is 30 to 60 inches. The mean annual air temperature is between 65° and 74° F. This pasture group makes up about 57,800 acres.

Drainage is good. Permeability is very rapid to moderate.

The vegetation in unimproved pasture is dominantly joee, Japanese tea, koa haole, lantana, bermudagrass, Natal redtop, rattailgrass, pricklypear cactus, and guava. There are dense stands of koa haole at the lower elevations. Unimproved pasture produces 2,000 to 3,200 pounds of air-dry forage per acre per year.

Forage species for improved pasture are kikuyugrass, pangolagrass, intortum, guineagrass, and green panicgrass. Koa haole grows well at elevations of less than 1,100 feet. Well-managed improved pasture produces 4,000 to 7,000 pounds of air-dry forage per acre per year.

Improvement of pasture is difficult on extremely stony, extremely rocky, very rocky, and very steep soils. Seeding, fertilization, and weed and brush control are limited to hand and aerial methods. Improvement on eroded soils is difficult because of low fertility and high erodibility.

PASTURE GROUP 6

This group consists of soils of the following series:

Alaeloa	Mahana
Halawa	Manana
Hamakuapoko	Naiwa
Ioleau	Oli
Kalae	Pohakupu
Kolekole	Puu Opae

These soils are on alluvial fans, terraces, and low uplands. They developed in alluvium, volcanic ash, and material weathered from basic igneous rocks. They are 24 to more than 60 inches deep. Slopes are dominantly 0 to 40 percent but range to as much as 70 percent on Alaeloa, Halawa, and Oli soils. The elevation ranges from 50 to 3,250 feet. The average annual rainfall is 30 to 60 inches. The mean annual air temperature is between 67° and 73° F. This pasture group makes up about 75,500 acres.

Drainage is good. Permeability is moderately rapid to slow.

The vegetation in unimproved pasture is dominantly hilograss, yellow foxtail, molassesgrass, Natal redtop, koa haole, joee, Japanese tea, guava, Christmas berry, and Java plum. There are dense stands of koa haole at the lower elevations. Unimproved pasture produces 2,400 to 3,200 pounds of air-dry forage per acre per year.

Forage species for improved pasture are kikuyugrass, pangolagrass, guineagrass, green panicgrass, intortum, and koa haole. Well-managed improved pasture produces 5,000 to 9,000 pounds of air-dry forage per acre per year.

Seeding, fertilization, and weed and brush control are limited to hand and aerial methods on the very steep soils. Improvement of pasture on eroded soils is difficult because of low fertility and high erodibility.

PASTURE GROUP 7

This group consists of soils of the Hanalei, Kaena, Kalihi, Kaloko, Keaau, Nohili, and Pearl Harbor series. These soils are on coastal plains, alluvial fans, terraces, and low uplands. They developed in alluvium, colluvium, and marine sediments. They are 20 to more than 60 inches deep. The slope range is dominantly 0 to 6 percent but ranges to 35 percent on Kaena soils. The elevation ranges from sea level to 300 feet. The average annual rainfall is 18 to 120 inches. The mean annual air temperature is between 73° and 75° F. This pasture group makes up about 19,500 acres.

Drainage is somewhat poor to very poor. Permeability is moderate to very slow.

The dominant vegetation in unimproved pasture is californiagrass, honohono, sensitiveplant, sedges, Java plum, and koa haole. Unimproved pasture produces 3,000 to 6,000 pounds of air-dry forage per acre per year. Forage production is well distributed throughout the year.

Forage species for improved pasture are pangolagrass, intortum, and californiagrass. Pangolagrass and intortum are suited to the better drained soils, californiagrass to the wetter soils. Well-managed improved pasture produces 7,000 to 16,000 pounds of air-dry forage per acre per year.

Improvement of pasture is difficult on the very stony Kaena soils. Seeding, fertilization, and weed and brush control are limited to hand and aerial methods.

PASTURE GROUP 8

This group consists of soils of the following series:

Haiku	Lolekaa
Hanamaulu	Makaalae
Hihimanu	Makawao
Honolua	Olelo
Kahanui	Paaloa
Kalapa	Paumalu
Kaneohe	Pauwela
Kolokolo	Puhi
Lawai	Waikane
Leilehua	

These soils are on alluvial fans, terraces, and low uplands. They developed in alluvium, colluvium, volcanic ash, and material weathered from basic igneous rocks. They are 30 to more than 60 inches deep. Slopes range from 0 to 70 percent. The elevation ranges from near sea level to 3,750 feet. The average annual rainfall is mainly 50 to 150 inches. The mean annual air temperature is between 62° and 73° F. This pasture group makes up about 112,800 acres.

Drainage is somewhat poor to moderate for Lawai soils and is good to moderate for the rest. Permeability is moderately rapid to moderate for all.

The vegetation in unimproved pasture is dominantly Japanese tea, bermudagrass, ricegrass, hilograss, carpetgrass, glenwoodgrass, yellow foxtail, honohono, paragrass, sensitiveplant, guava, lantana, Christmas berry, koa, and ohia. Unimproved pasture produces 3,000 to

5,000 pounds of air-dry forage per acre per year. Forage production is well distributed throughout the year.

Forage species for improved pasture are kikuyugrass, pangolagrass, and intortum (fig. 14). Well-managed improved pasture produces 8,000 to 14,000 pounds of air-dry forage per acre per year.

Improvement of pasture is difficult on extremely stony, very rocky and bouldery soils and very steep soils. Seeding, fertilization, and weed and brush control are limited to hand and aerial methods. Improvement of pasture on eroded soils is difficult because of low fertility and high erodibility.

PASTURE GROUP 9

This group consists of soils of the Hana variant, Malama, Niulii, Opihikao, and Tantalus series. These soils are on recent lava flows, cinder cones, and low uplands. They developed in volcanic ash, cinders, organic material, and material weathered from basic igneous rocks. They are less than 10 inches to more than 40 inches deep. Slopes are dominantly 0 to 30 percent but range to 70 percent on Tantalus soils. The elevation ranges from near sea level to 2,200 feet. The average annual rainfall is mainly 60 to 100 inches but ranges from 50 to 150. The mean annual air temperature is between 70° and 72° F. This pasture group makes up about 8,900 acres.

Drainage is good except in depressions in the very shallow Opihikao soils. In these soils ponding is common. Permeability is moderately rapid to very rapid. This pasture group makes up about 8,900 acres.

The vegetation in unimproved pasture is dominantly hilograss, guava, kukui, hala, and ohia. Unimproved pasture produces 3,000 to 5,000 pounds of air-dry forage per acre per year. Forage production is well distributed throughout the year.

Forage species for improved pasture are kikuyugrass, pangolagrass, and intortum. Well-managed improved pasture produces 8,000 to 14,000 pounds of air-dry foragr per acre per year.

Except on Niulii soils, improvement of pasture is difficult because of the extremely stony and rocky conditions or the very steep slopes. Seeding, fertilization, and weed and brush control are limited to hand and aerial methods.

PASTURE GROUP 10

This group consists of soils of the Halii, Kapaa, Makapili, and Pooku series. These soils are on low uplands. They developed in material weathered from basic igneous rocks. They are more than 60 inches deep. Slopes range

Figure 14.—Intortum pasture on a Makawao soil.

from 0 to 40 percent except for the very steep Kapaa soils. The elevation ranges from 100 to 1,800 feet. The average annual rainfall is 70 to 200 inches. The mean annual air temperature is between 70° and 73° F. This pasture group makes up about 37,700 acres.

Drainage is good to moderately good. Permeability is moderately rapid.

The vegetation in unimproved pasture is dominantly ricegrass, hilograss, yellow foxtail, lantana, joee, false staghornfern, melastoma, rhodomyrtus, sensitiveplant, guava, Christmas berry, and ohia. Unimproved pasture produces 3,000 to 5,000 pounds of air-dry forage per acre per year. Forage production is well distributed throughout the year.

Forage species for improved pasture are kikuyugrass, pangolagrass (fig. 15), and intortum. Well-managed improved pasture produces 8,000 to 10,000 pounds of air-dry forage per acre per year.

Improvement of pasture is difficult on the very steep Kapaa soils. Seeding, fertilization, and weed and brush control are limited to hand and aerial methods. Improvement on the eroded Halii soils is difficult because of low fertility.

PASTURE GROUP 11

This group consists of soils of the Hana, Kailua, Koolau, and Honomanu series. These soils are on uplands. They developed in volcanic ash. They are 20 to 50 inches deep. Slopes range from 0 to 25 percent. The elevation ranges from near sea level to 2,000 feet. The average annual rainfall is 80 to 250 inches. The mean annual temperature is between 65° and 75° F. This pasture group makes up about 16,600 acres.

Drainage is good. Permeability is moderately rapid.

The vegetation in unimproved pasture is dominantly ricegrass, hilograss, kaimiclover, false staghornfern, treefern, guava, kukui, ohia and koa. Unimproved pasture produces 3,000 to 5,000 pounds of air-dry forage per acre per year. Forage production is well distributed throughout the year.

Forage species for improved pasture are kikuyugrass, pangolagrass, intortum, and big trefoil. Well-managed improved pasture produces 8,400 to 14,000 pounds of air-dry forage per acre per year.

Improvement of pasture is difficult on the extremely stony Hana soils. Seeding, fertilization, and weed and brush control are limited to hand and aerial methods.

PASTURE GROUP 12

This group consists of soils of the Kokee, Kunuweia, Olinda, and Paaiki series. These soils are on intermediate uplands. They developed in volcanic ash and material weathered from basic igneous rocks. They are 20 to more than 60 inches deep. Slopes are dominantly 0 to 40 percent but range to 70 percent on Kokee and Paaiki soils. The elevation ranges from 2,500 to 5,000 feet. The average annual rainfall is mainly 40 to 70 inches but ranges to 150 inches on Kunuweia soils. The mean air tempera-

Figure 15.—Pangolagrass pasture on Pooku soil in East Kauai.

ture is between 57° and 60° F. This pasture group makes up about 14,100 acres.

Drainage is good. Permeability is moderately rapid.

The vegetation in unimproved pasture is dominantly false staghornfern, yellow foxtail, koa, guava, Christmas berry, ohia, and puakeawe. Unimproved pasture produces 2,200 to 3,500 pounds of air-dry forage per acre per year. Forage production is well distributed throughout the year.

Forage species for improved pasture are kikuyugrass, orchardgrass, and big trefoil. Intortum grows well at the lower elevations. Well-managed improved pasture produces 4,200 to 8,000 pounds of air-dry forage per acre per year.

Improvement of pasture is difficult on the extremely stony and stony soils that are mapped as complexes. Seeding, fertilization, and weed and brush control are limited to hand and aerial methods on the very steep Kokee and Paaiki soils.

PASTURE GROUP 13

This group consists of soils of the Kaipoioi and Laumaia series. These soils are on intermediate and high uplands. They developed in volcanic ash. They are 40 to more than 60 inches deep. Slopes are mainly 7 to 40 percent but range to 70 percent on Laumaia soils. The elevation ranges from 3,500 to 8,000 feet. The average annual rainfall is 30 to 50 inches. The mean annual air temperature is between 49° and 57° F. This pasture group makes up about 21,500 acres.

Drainage is good. Permeability is moderately rapid.

The vegetation in unimproved pasture is dominantly rattailgrass, sweet vernal, Yorkshire fog, and puakeawe. Unimproved pasture produces 1,800 to 3,000 pounds of air-dry forage per acre per year. Forage production is well distributed throughout the year.

Forage species for improved pasture are orchardgrass, kikuyugrass, white clover, and red clover. Well-managed improved pasture produces 3,500 to 6,500 pounds of air-dry forage per acre per year.

Seeding, fertilization, and weed and brush control are limited to hand and aerial methods on the very rocky Kaipoioi soils and the very steep Laumaia soils.

PASTURE GROUP 14

This group consists of land types on alluvial fans, terraces, and uplands. The soil material is derived from basic igneous rocks, alluvium, colluvium, and volcanic ash. The soil depth ranges from very shallow to more than 60 inches. Slopes range from nearly level to very steep. The elevation ranges from near sea level to about 8,000 feet. The annual rainfall ranges from 15 to more than 100 inches. The mean annual air temperature is between 49° and 75° F.

Drainage is good to excessive.

This pasture group is extremely variable because of the wide range in rainfall, elevation, temperature, and soil characteristics. The vegetation and forage production of each land type are similar to those of associated soils.

No reference is made in the "Guide to Mapping Units" for pasture group 14.

Woodland Management [3]

Approximately 396,000 acres in the survey area is used for commercial timber. Most of the commercial woodland consists of introduced species. For this reason, site preparation that involves rough land clearing is often needed before planting to remove competing plants. Generally, plantings are made at 8x8- to 12x12-foot spacings. After regeneration is established and until the seedlings are well established, competing grasses, ferns, shrubs, or tree reproductions are removed. To insure adequate tree survival and good form, the initial plantings are generally closer than needed. The removal of surplus trees by thinning between the ages of 5 and 20 years improves the growth and quality of the merchantable tree crop. Only the trees left for later cuttings are pruned. Periodic commercial thinnings maintain a fast growth rate on the remaining quality trees. When the stand has reached a desired size, it is harvested either by a system of clearcutting or by some type of shelterwood cutting.

Access and protection are of primary importance to any feasible land-use program. Good roads should be developed and maintained on grades of less than 12 percent and protected by water bars and culverts.

The degrees of hazards and limitations for growing wood crops are explained in the following paragraphs.

Seedling mortality is the mortality of naturally occurring or planted tree seedlings as influenced by the quality of soil, the topographic features, and the climate. A rating of *slight* indicates that expected mortality is less than 25 percent. A rating of *moderate* indicates an estimated mortality of between 25 and 50 percent. A rating of *severe* indicates that the mortality rate is more than 50 percent. These ratings indicate the expected survival from natural regeneration or planting, the choice and intensity of seedbed treatment, the grade of planting stock and type of planting methods, and the possibility of interplanting or replanting for establishment of an adequate stand.

Plant competition is the invasion or growth of undesirable plant species. A rating of *slight* indicates that competition does not prevent adequate natural regeneration and growth or interfere with development of planted seedlings. A rating of *moderate* indicates that competition delays natural or artificial regeneration in both establishment and growth rate but does not prevent the eventual development of adequately stocked stands. A rating of *severe* indicates that competition prevents adequate regeneration unless there is intensive site preparation and followup weeding. These ratings indicate the choice of species, the method of regeneration, the intensity of soil preparation, the required stand treatment, and the probability of obtaining adequate and immediate restocking.

Equipment limitation refers to characteristics of the soils that restrict or prevent the use of equipment commonly used in tending and harvesting the trees. A rating of *slight* indicates that equipment is not restricted in kind or time of year. A rating of *moderate* indicates that equipment is moderately restricted because of slope, stones or obstructions, seasonal soil wetness, or physical soil

[3] JOHN HULTGREN, woodland conservationist, SCS, assisted in the preparation of this section.

characteristics. A rating of *severe* indicates that special equipment is needed.

Erosion hazard indicates the degree of potential soil erosion. Soil erosion in woodland seldom occurs until the vegetation is disturbed or destroyed by fire, excessive grazing, logging, or roadbuilding. Erosion becomes a major problem during roadbuilding and logging operations. The slope, the stability of the soil, the permeability and water-holding capacity, and the effects of past erosion all influence the rating. A rating of *slight* indicates only minor problems. A rating of *moderate* indicates that measures are needed to control erosion. A rating of *severe* indicates that intensive treatment and specialized equipment and methods of operation must be applied.

Windthrow hazard indicates the possibility of trees being blown over by wind. A rating of *slight* indicates that trees in forested areas are not likely to be blown down by commonly occuring winds. A rating of *moderate* indicates that some trees are expected to blow down during high winds because of soil shallowness or wetness.

Woodland groups

The soils of the islands are grouped according to their suitability for woodland. Each group is made up of soils that produce similar kinds of wood crops, need similar management, and have about the same potential productivity. There are 16 groups. Each is described in the following pages. For each group, the species suitable for producing wood crops are named, estimated productivity is given, and the relative degrees of hazards and limitations for growing wood crops are given.

Ohia and koa are the main native species satisfactory for production of commercial timber. Foresters consider these species inferior, slow growing, or difficult to reestablish. Most of the suitable species mentioned in the following pages are exotics. These introduced trees are considered the most suitable commercial species now known.

At present, there are no site or yield tables for any species grown in Hawaii. Nevertheless, many stands of trees that have a known age have been measured, and yields have been estimated, based on a 30-60-year cutting cycle. Annual productivity is estimated in board feet (International ½″ rule). The variation in growth among the species accounts for the wide range in productivity within a group.

The names of the soil series represented are mentioned in the description of each group, but this does not mean that all the soil mapping units of a given series are in the group. To find the woodland classification for each soil, refer to the "Guide to Mapping Units."

WOODLAND GROUP 1

This group consists of soils of the following series:

Haleiwa	Lahaina
Haliimaile	Niu
Kahana	Papaa
Kaupo	Waialua
Kawaihapai	Wailuku
Kunia	

These are well drained to moderately well drained clay loams, silty clays, and clays that developed in residuum and alluvium derived from basalt and andesite. They are on low uplands and also in intermittent drainageways and on alluvial fans on the coastal plains. Kaupo soils are 20 to 40 inches deep, and the rest are more than 60 inches deep. The elevation ranges from sea level to 1,800 feet. The slope ranges from 0 to 40 percent except for a small area of Papaa soils where it is more than 40 percent. The average annual rainfall is 22 to 60 inches.

Suitable species are monkeypod, Norfolk Island pine, silk oak, saligna eucalyptus, and blackbutt eucalyptus. The estimated annual productivity is 100 to 500 board feet per acre. Seedling mortality is moderate to severe. Plant competition from koa haole, guava, and grasses is slight to moderate. The equipment limitation is severe on the very steep Papaa soil but is slight on the rest. The erosion hazard is slight, and the windthrow hazard is slight.

WOODLAND GROUP 2

This group consists of soils of the Kula and Io series. They are well-drained loams and silt loams that developed in volcanic ash. They are gently sloping to moderately steep and are on uplands. They are 20 to more than 40 inches deep over cinders or bedrock. The elevation ranges from 1,000 to 3,500 feet. The average annual rainfall is 25 to 40 inches.

Suitable species are loblolly pine, slash pine, cluster pine, gray ironbark eucalyptus, and red ironbark eucalyptus. The estimated annual productivity is 100 to 200 board feet per acre. Seedling mortality is moderate to severe. Plant competition is slight. The equipment limitation is moderate on the very rocky Kula soils but is slight on the rest. The erosion hazard is moderate to severe. The windthrow hazard is slight.

WOODLAND GROUP 3

This group consists of soils of the Kaimu, Pane, and Ulupalakua series. These are well-drained soils that developed in volcanic ash and cinders and in organic matter. They are moderately sloping to moderately steep and are on intermediate uplands. The Kaimu soil is 3 to 8 inches deep over fragmental Aa lava. The others are 24 to more than 40 inches deep over fine cinders or fragmental Aa lava. The elevation ranges from 1,000 to 4,500 feet. The slope ranges from 7 to 25 percent. The average annual rainfall is 30 to 50 inches.

Suitable species are saligna eucalyptus, lemon-gum eucalyptus, tallowwood eucalyptus, blackbutt eucalyptus, loblolly pine, slash pine, Monterey pine, and Norfolk Island pine. The estimated annual productivity is 200 to 500 board feet per acre. Seedling mortality, plant competition, the equipment limitation, and the windthrow hazard are all slight. The erosion hazard is moderate.

WOODLAND GROUP 4

This group consists of soils of the following series:

Hanalei	Kekaha
Kaena	Lualualei
Kalihi	Pakala
Keaau	Pearl Harbor

These are poorly drained or very poorly drained silty clays and clays that developed in alluvium and colluvium derived from basalt and andesite. They are on alluvial fans, colluvial slopes, and coastal plains. Pearl Harbor soils are 20 to 50 inches deep over muck or peat. The

rest are more than 60 inches deep. The elevation ranges from sea level to 300 feet. The slope ranges from 0 to 35 percent. The average annual rainfall is 18 to 100 inches.

A suitable species is robusta eucalyptus. The estimated annual productivity is 300 to 800 board feet per acre. Seedling mortality is slight to moderate. Plant competition from californiagrass is severe. The equipment limitation is severe. The erosion hazard is moderate on the steeper Kaena soils but is slight on the rest. The windthrow hazard is moderate.

WOODLAND GROUP 5

This group consists of soils of the following series:

Alaeloa	Mahana
Halawa	Naiwa
Hamakuapoko	Oli
Kalae	Pohakupu
Kemoo	Puu Opae
Koloa	Wahiawa
Lihue	

These are well-drained silt loams, silty clay loams, and silty clays that developed in alluvium, colluvium, and residuum derived from basalt and andesite, and in volcanic ash. They are on terraces, alluvial fans, and low uplands. They are 20 to more than 60 inches deep. The elevation ranges from near sea level to 3,000 feet. The slope ranges from 0 to 40 percent. The average annual rainfall is 30 to 60 inches.

Suitable species are saligna eucalyptus, blackbutt eucalyptus, and Norfolk Island pine. Slash pine and loblolly pine are suitable at elevations above 1,600 feet (fig. 16) and monkeypod at elevations below 1,000 feet. The estimated annual productivity is 700 to 1,000 board feet. Seedling mortality is slight to moderate. Plant competition from guava, Christmas berry, koa haole, and grasses is moderate. The equipment limitation and the erosion hazard are both slight to moderate. The windthrow hazard is slight.

WOODLAND GROUP 6

This group consists of soils of the Ioleau, Kolekole, and Manana series. These are well-drained silty clay loams and silty clays that developed in old alluvium and residuum derived from basalt and andesite. They are on low uplands. They are 15 to 50 inches deep over a compact, panlike layer. The elevation ranges from 100 to 1,200 feet. The slope ranges from 0 to 40 percent. The average annual rainfall is 35 to 70 inches.

Suitable species are saligna eucalyptus, blackbutt eucalyptus, silk-oak, and monkeypod. The estimated annual

Figure 16.—Six-year-old plantings of slash pine on a Naiwa silty clay loam, woodland group 5. The trees are about 10 feet tall.

productivity is 200 to 600 board feet. Seedling mortality is moderate. Plant competition from koa haole, Christmas berry, and grasses is slight to moderate. The equipment limitation is slight. The erosion hazard is slight to moderate. The windthrow hazard is moderate to severe.

WOODLAND GROUP 7

This group consists of soils of the following series:

Haiku	Makaalae
Hanamaulu	Makawao
Honolua	Olelo
Kalapa	Paaloa
Kaneohe	Paumalu
Kolokolo	Pauwela
Lawai	Puhi
Leilehua	Waikane
Lolekaa	

These are well-drained silt loams, silty clay loams, silty clays, and clays that developed in alluvium, colluvium, and residuum derived from basalt and andesite, and in volcanic ash. They are on fans, terraces, and low uplands. They are 30 to more than 60 inches deep. The elevation ranges from 0 to 2,200 feet. The slope ranges from 0 to 40 percent. The average annual rainfall is 50 to 100 inches.

Suitable species are saligna eucalyptus, tallowwood eucalyptus, robusta eucalyptus, Norfolk Island pine, and albizzia. Monkeypod is suitable at elevations of less than 1,000 feet. The estimated annual productivity is 500 to 1,500 board feet per acre. Seedling mortality is slight. Competition from false staghornfern, guava, Christmas berry, and grasses is moderate to severe. The equipment limitation and the erosion hazard are both slight to moderate. The windthrow hazard is slight.

WOODLAND GROUP 8

This group consists of soils of the Hana, Kailua, Malama, Niulii, Tantalus, and Honomanu series. These are well-drained silt loams, silty clay loams, and silty clays that developed in volcanic ash and cinders. They are 15 to more than 60 inches deep over cinders, fragmental Aa lava, or soft weathered rock. The elevation is dominantly from near sea level to 2,000 feet, but ranges to 4,500 feet for Honomanu soils. The slope ranges from 3 to 70 percent. The average annual rainfall is dominantly 90 to 150 inches but measures as little as 50 inches on Tantalus soils and as much as 250 inches on Honomanu soils.

Suitable species are saligna eucalyptus, robusta eucalyptus, Nepal alder, Norfolk Island pine, Australian toon, Queensland maple, tropical ash, blackwood, sugi, and redwood. Monkeypod is suitable below an elevation of 1,000 feet. Ohia and koa are well suited native species. The estimated annual productivity is 600 to 1,200 board feet per acre. Seedling mortality is slight. Plant competition from treefern, false staghornfern, melastoma, downy rosemyrtle, and kikuyugrass is severe. The equipment limitation is moderate to severe. The erosion and windthrow hazards are slight.

WOODLAND GROUP 9

This group consists of soils of the Halii, Kapaa, Makapili, and Pooku series. These are well drained to moderately well drained silty clay loams and silty clays that developed in material weathered from basalt and andesite. They are gently sloping to steep and are on dissected low uplands. They are more than 60 inches deep. The elevation ranges from near sea level to 1,000 feet. The slope ranges from 0 to 40 percent. The average annual rainfall is 70 to 200 inches.

Suitable species are saligna eucalyptus, blackbutt eucalyptus, robusta eucalyptus, tallowwood eucalyptus, lemon-gum eucalyptus, Nepal alder, albizzia, monkeypod, Norfolk Island pine, Australian toon, and Queensland maple. The estimated annual productivity is 400 to 800 board feet per acre. Seedling mortality is slight. Plant competition is severe from melastoma, rhodomyrtus, false staghornfern, and guava. The equipment limitation is slight. The erosion hazard is slight to moderate. The windthrow hazard is slight.

WOODLAND GROUP 10

This group consists of soils of the Kokee, Olinda, and Paaiki series. These are well-drained silty clay loams and heavy loams that developed in volcanic ash and in residuum derived from basalt and andesite. They are on intermediate uplands. They are more than 36 inches deep over weathered basalt and andesite. The elevation ranges from 2,500 to 5,000 feet. The slope is dominantly 0 to 40 percent but ranges to 70 percent on Kokee and Paaiki soils. The average annual rainfall is 40 to 70 inches.

Suitable species are saligna eucalyptus, tallowwood eucalyptus, robusta eucalyptus, blackbutt eucalyptus, slash pine, loblolly pine, Monterey pine, Australian toon, albizzia, tropical ash, redwood, sugi, and blackwood. The estimated annual productivity is 400 to 1,500 board feet per acre. Seedling mortality is slight. Plant competition is slight. The equipment limitation is slight if the slope is less than 35 percent and severe if it is more than 35 percent. The erosion hazard is moderate if the slope is less than 35 percent and severe if it is more than 35 percent. The windthrow hazard is severe.

WOODLAND GROUP 11

This group consists of soils of the Kaipoioi, Laumaia, and Uma series. These are well-drained to excessively drained silt loams, loams, and loamy coarse sands that developed in volcanic ash and fine cinders. They are on intermediate to high uplands. Laumaia and Kaipoioi soils are more than 40 inches deep over cinders or rock. Uma soils are less than 10 inches deep over fine cinders. The elevation is dominantly 3,500 to 8,000 feet. The slope is dominantly 7 to 40 percent but ranges to 70 percent on Laumaia and Uma soils. The average annual rainfall is dominantly 35 to 60 inches.

Suitable species for Kaipoioi and Laumaia soils are saligna eucalyptus, blackbutt eucalyptus, sugi, redwood, Monterey pine, and tropical ash. The estimated annual productivity is 400 to 600 board feet per acre. Suitable species for Uma soils are Jeffery pine or cluster pine, on a trial basis. The estimated annual productivity on these soils is 50 to 200 board feet per acre. Seedling mortality is slight to moderate on Kaipoioi and Laumaia soils and severe on Uma soils. Plant competition is slight. The equipment limitation is slight to moderate if the slope is less than 40 percent and severe if it is more than 40 percent. The erosion hazard is moderate on Kaipoioi and

Laumaia soils and severe on Uma soils if the slope is less than 40 percent. It is severe on Laumaia soils if the slope is more than 40 percent. The windthrow hazard is slight.

WOODLAND GROUP 12

This group consists of soils of the Kahanui and Kunuweia series. These are well drained to moderately well drained gravelly clay loams and gravelly silty clays that developed in residuum derived from basalt and andesite. These soils are gently sloping to moderately sloping and are on intermediate uplands. They are 10 to 24 inches deep over a discontinuous ironstone sheet or soft weathered rock. The elevation ranges from 1,250 feet to 4,000 feet. The slope ranges from 0 to 20 percent. The average annual rainfall is dominantly 60 to 150 inches. On the island of Lanai, it measures 35 inches, but the amount of moisture is equivalent to 80 inches because of fog drip and cloud cover.

Suitable species are saligna eucalyptus, robusta eucalyptus, blackbutt eucalyptus, Nepal alder, Norfolk Island pine, slash pine, loblolly pine, redwood, sugi, and blackwood. The estimated annual productivity is 200 to 600 board feet per acre. Seedling mortality is slight. Plant competition is moderate. The equipment limitation is slight, and the erosion hazard is slight. The windthrow hazard is moderate to severe.

WOODLAND GROUP 13

This group consists of soils of the Waikomo and Kalaupapa series. These are well-drained silty clay loams and silty clays that developed in volcanic ash and in residuum derived from basalt and andesite. These soils are gently sloping to moderately steep and are on low uplands. They are less than 20 inches deep over bedrock. The elevation ranges from near sea level to 400 feet. The slope ranges from 3 to 25 percent. The average annual rainfall is 35 to 60 inches.

Monkeypod is the most suitable species. The estimated annual productivity is 100 to 300 board feet per acre. Seedling mortality is moderate. Plant competition from koa haole and lantana is moderate. The equipment limitation and the erosion hazard are both slight to moderate. The windthrow hazard is severe.

WOODLAND GROUP 14

This group consists of soils of the Hihimanu, Kalapa, Kaneohe, Kapaa, Lolekaa, Paumalu, and Waikane series. These are well-drained silty clay loams and silty clays that developed in volcanic ash and in alluvium, colluvium, and residuum derived from basalt and andesite. They are on fans, terraces, and low uplands. The depth to soft weathered rock is 30 to more than 60 inches. The elevation ranges from sea level to 2,000 feet. The slope ranges from 30 to 100 percent. The average annual rainfall is dominantly 60 to 90 inches but ranges from 50 to 120 inches.

Suitable species are saligna eucalyptus, tallowwood eucalyptus, robusta eucalyptus, and Norfolk Island pine. The estimated annual productivity is 500 to 1,500 board feet per acre. Seedling mortality is slight. Plant competition from guava, Christmas berry, false staghornfern, and grasses is moderate to severe. The equipment limitation and the erosion hazard are both severe. The windthrow hazard is slight.

WOODLAND GROUP 15

This group consists of Colluvial land and soils of the Alaeloa, Halawa, Helemano, Kemoo, and Oil series. These are well-drained silt loams, silty clay loams, and silty clays that developed in volcanic ash and in colluvium and residuum derived from basalt and andesite. They are on colluvial slopes and low uplands. The depth to highly weathered rock is 25 to more than 60 inches. The elevation ranges from near sea level to 3,000 feet. The slope ranges from 30 to 90 percent. The average annual rainfall is 30 to 60 inches.

Suitable species are saligna eucalyptus, blackbutt eucalyptus, and Norfolk Island pine. The estimated annual productivity is 700 to 1,000 board feet per acre. Seedling mortality is slight to moderate. Plant competition from guava, Christmas berry, koa haole, and grasses is moderate. The equipment limitation and the erosion hazard are both severe. The windthrow hazard is slight.

WOODLAND GROUP 16

This group consists of Alakai mucky peat and soils of the Amalu, Hulua, Koolau, Olokui, and Waialeale series. These are poorly drained to very poorly drained upland soils that developed in organic material and volcanic ash, and in residuum derived from basalt and andesite. They are 15 to more than 60 inches deep. The elevation is dominantly 1,500 to 5,000 feet, but there are small areas at lower elevations. The slope is dominantly less than 30 percent, but it ranges to 70 percent for Hulua and Waialeale soils. The average annual rainfall is 75 to more than 400 inches. Fog and cloud cover, which are present most days throughout the year, significantly increase the amount of effective moisture over most of the area.

This group is of little value for commercial woodland. Its best use is for water supply and for the woodland plants that have commercial value for flower arrangements, leis, and landscape plantings, such as treefern, clubmoss, swordfern, lacefern, and mokihana. Treefern is also used for fences and tiki carvings and as a media for growing orchids, anthuriums, and other plants. The equipment limitation and the windthrow hazard are both severe.

Truck Crop Management

A variety of vegetable crops is commercially produced for local consumption. Lettuce, cabbage, cucumber, snap beans, tomatoes, onions, peppers, broccoli, corn, eggplant, and gingerroot are the major crops. All have similar management.

Soil preparation consists of disk harrowing to chop plant residue. This is followed by plowing and smoothing.

Soil fumigants are used before planting to control nematodes.

The kind of fertilizer and the rate and time of application vary and depend on the soil and the crop. They are best determined by soil tests, field trials, and experience. Fertilizers are applied in dry form or in liquid form, by foliar application. Nitrogen, phosphorus, and potassium

are beneficial. Minor elements and lime are applied as needed.

Most vegetable crops require frequent irrigation. Both overhead and furrow irrigation are used.

Weeds are controlled by chemicals and by mechanical and hand weedings. Both preemergence and contact herbicides are used. Insects and fungi are controlled by chemicals.

Windbreaks are needed to protect vegetable crops in areas exposed to strong winds.

Orchard Management

Bananas, papayas, and macadamia nuts are the most commonly grown orchard crops in this area.

Bananas are relatively easy to grow but require good management. New plants are generally started from suckers removed from the parent plant. The Chinese and Bluefield varieties are the two most important commercial varieties. The time required to grow a crop is about 1 year, depending on climate, soil, and other factors.

Bananas require abundant moisture and good drainage. Applications of trash mulch and shallow cultivation help in controlling weeds. A complete fertilizer is needed three or more times a year. The rate of application depends on the soil, the amount of rainfall, and the size of the plants. Yields are about 20,000 pounds per acre per year.

Papayas grow well along the coastal plains and on the uplands to an elevation of about 1,000 feet. The solo papaya is the most common variety grown. The plants are started from seeds, generally in seed flats, and are then transferred to the field. Unlike other orchard crops, papaya is a short-term crop. It begins to produce marketable fruit at the end of the first year and is normally productive for about 3 years. After the third year, the trees grow too tall and harvesting becomes difficult.

Soil preparation for papayas consists of plowing and harrowing. On sloping soil where the erosion hazard is severe, papaya plants are planted on the contour. A complete fertilizer, high in phosphorus, is applied at planting time and at frequent intervals thereafter. If the amount of rainfall is inadequate, the plants are irrigated by sprinklers or furrows. Weeds are controlled by chemicals or by machine or hand weeding. Insects and disease are controlled by chemicals. Papaya trees are easily damaged by wind, so windbreaks are needed in areas exposed to tradewinds.

Macadamia trees grow at elevations that range from sea level up to 2,500 feet. They grow best in areas where the annual rainfall is 50 to 120 inches. Only grafted trees of the best varieties should be planted. The three most promising varieties are Kakea, Ikaika, and Keauhou. They take about 7 years to come into commercial production. Yields vary between 2,500 and 3,500 pounds per acre per year, depending on the climate and the soil.

Herbicides are used to control weeds. A complete fertilizer is applied 3 to 5 times a year. The rate and frequency of applications vary, depending on the soil, the amount of rainfall, and the size of the plants. Control of anthracnose, nut borers, and rats are essential for maximum production. Windbreaks are needed in areas exposed to strong winds.

Capability Grouping

Capability grouping shows, in a general way, the suitability of soils for most kinds of crops. The groups are made according to the limitations of the soils when used for crops, the risk of damage when they are used, and the way they respond to treatment. The grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils, and does not take into consideration possible but unlikely major reclamation projects.

Those familiar with the capability classification can infer from it much about the behavior of soils when used for other purposes, but this classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for range, for forest trees, or for engineering.

In this publication all kinds of soil are grouped at two levels, the capability class and the subclass. The classification is designated in the "Guide to Mapping Units" for all soils on the islands, both irrigated and nonirrigated soils. The classification is described in the following paragraphs.

Capability Classes, the broadest groups, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use.

Capability Subclasses are soil groups within one class; they are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in only some parts of the United States, shows that the chief limitation is climate that is too cold or too dry.

In class I there are no subclasses because the soils of this class have few limitations. Class V can contain, at the most, only the subclasses indicated by *w*, *s*, and *c*, because the soils in class V are subject to little or no erosion, though they have other limitations that restrict their use largely to pasture or range, woodland, wildlife habitat, or recreation.

The eight classes in the capability system and the subclasses represented on the islands are defined as follows:

Class I soils have few limitations that restrict their use. (No subclasses)

Class II soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.

Subclass IIe soils are subject to moderate erosion if they are cultivated and not protected. The soils are 30 to more than 60 inches deep and have slopes of 0 to 8 percent.

Subclass IIw soils have moderate limitations because of excess water. The soils are poorly drained, are subject to seasonal flooding, and have slopes of 0 to 2 percent.

Subclass IIs soils have moderate limitations of stoniness, unfavorable texture, shallowness, or low water-holding capacity. The soils are more than 20 inches deep and have slopes of 0 to 2 percent.

Subclass IIc soils have moderate limitations because of climate. The soils are slightly droughty because of limited rainfall. They are well drained, are more than 60 inches deep, and have slopes of 0 to 2 percent.

Class III soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.

Subclass IIIe soils are subject to severe erosion if they are cultivated and not protected. In most places the soils are more than 20 inches deep and have slopes of 0 to 15 percent.

Subclass IIIw soils have severe limitations because of excess water. The soils are poorly drained or subject to seepage, are more than 20 inches deep, and have slopes of 0 to 12 percent.

Subclass IIIs soils have severe limitations because of stoniness, unfavorable texture, shallowness, or low water-holding capacity. The soils are well drained, are more than 20 inches deep, and have slopes of 0 to 8 percent.

Subclass IIIc soils have severe limitations because of climate. These soils are droughty because of limited rainfall. They are well drained to moderately well drained, are more than 36 inches deep, and have slopes of 0 to 8 percent.

Class IV soils have very severe limitations that reduce the choice of plants, require very careful management, or both.

Subclass IVe soils are subject to severe erosion if they are cultivated and not protected. The soils are well drained to moderately well drained, are more than 20 inches deep, and have slopes of 0 to 25 percent.

Subclass IVw soils have very severe limitations because of excess water. The soils are poorly drained or very poorly drained or subject to seepage, are more than 20 inches deep, and have slopes of 0 to 20 percent.

Subclass IVs soils have very severe soil limitations because of stoniness, shallowness, unfavorable texture, or low water-holding capacity. In places the soils are stony. They are well drained to excessively drained, are more than 20 inches deep, and have slopes of 0 to 20 percent.

Subclass IVc soils have very severe limitations because of climate. These soils are very droughty because of limited rainfall. They are well drained, are more than 20 inches deep, and have slopes of 0 to 8 percent.

Class V soils are not likely to erode but have other limitations, impractical to remove, that limit their use largely to pasture or range, woodland, or wildlife habitat.

Subclass Vw soils have very severe limitations because of excess water. The soils are poorly drained, are more than 20 inches deep, and have slopes of 0 to 2 percent.

Class VI soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife habitat.

Subclass VIe soils are severely limited by the hazard of erosion. The soils are well drained, are more than 20 inches deep, and have slopes of 6 to 40 percent.

Subclass VIw soils are severely limited by excess water. The soils are poorly drained and have slopes of 12 to 20 percent.

Subclass VIs soils have very severe limitations because of stoniness or unfavorable texture. The soils are very stony, very rocky, extremely stony, or extremely rocky, and have slopes of 0 to 35 percent.

Subclass VIc soils have very severe limitations because of climate. These soils are very droughty because of limited rainfall. They are more than 36 inches deep and have slopes of 0 to 6 percent.

Class VII soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to pasture or range, woodland, or wildlife habitat.

Subclass VIIe soils are very severely limited by risk of erosion. The soils are well drained to excessively drained and have slopes that range from 0 to 100 percent.

Subclass VIIw soils are very severely limited by excess water. The soils are on mountain summits or within closed craters and are very poorly drained. Slopes range from 0 to 20 percent.

Subclass VIIs soils have very severe soil limitations because of unfavorable texture, or because they are extremely rocky or stony. Also included are land types that are steep, rocky, or stony.

Class VIII soils and landforms have limitations that preclude their use for commercial plant production and restrict their use to recreation, wildlife habitat, or water supply, or to esthetic purposes.

Subclass VIIIe soils are subject to very severe erosion if the existing cover is removed. These are areas of very steep, shallow, rough mountainous land.

Subclass VIIIw soils are severely limited by excess water, but may be used for wildlife habitat, watershed protection, or recreation. These are areas of marshes.

Subclass VIIIs soils have very severe limitations that restrict their use for wildlife habitat or recreation. These are areas of cinderland, outcrops, or coastal beaches.

Wildlife Production

Wildlife production is an important land use on the islands of Molokai, Lanai, Maui, and Kauai. It is a primary land use on two-thirds of the island of Lanai and a secondary land use on many of the pasturelands and woodlands in the survey area. There are several public shooting grounds on private and State lands that are managed by the State Division of Fish and Game. In addition there are other private lands that produce wildlife for hunting by landowners and their guests.

Several species of big game animals and game birds are available for hunting. The axis deer is the most sought after big game animal. The deer occurs throughout the islands of Molokai and Lanai, from the dry lowlands to the rain forest of the uplands. The mouflon sheep, introduced in 1956 on Lanai and Kauai, has recently become available for hunting. Antelope also has been recently introduced and established on Lanai. Wild goats are on all the islands, and wild pigs on all except Lanai.

Game birds available for hunting are ring-necked pheasants, California and Japanese quails, barred doves, lace-necked doves, chuckar partridge, Indian grey francolins, and Indian black francolins. These francolins are recent introductions and have become established in a short time. Another recently introduced game species, the Rio Grande turkey, is not yet available for hunting.

Bass and bluegill are stocked in some plantation reservoirs. Rainbow trout is found in streams in the Kokee area of Kauai.

Wildlife is usually compatible in woodland and pasture and can be a secondary use of these lands. On soils that are severely eroded, very stony, very rocky, or very steep, wildlife production can be an important land use. Such land types have low potential for pasture and other uses but have high potential for wildlife production.

Engineering Uses of the Soils [4]

This section provides information of special interest to engineers, contractors, farmers, and others who use soil as structural material or as foundation material upon which structures are built. Information is given in this section about those properties of the soils that affect construction and maintenance of roads and airports, pipelines, building foundations, water storage facilities, erosion control structures, drainage systems, and sewage disposal systems. Among the soil properties most important in engineering are permeability, shear strength, shrink-swell potential, water-holding capacity, and reaction.

Information concerning these and related soil properties are furnished in tables 2, 3, and 4. The estimates and interpretations of soil properties in these tables can be used in—

1. Planning and designing agricultural drainage systems, farm ponds, irrigation systems, diversion terraces, and other structures for controlling water and conserving soils.
2. Selecting potential locations for highways, airports, pipelines, and underground cables.
3. Locating probable sources of sand, gravel, or rock suitable for use as construction material.
4. Selecting potential industrial, commercial, residential, and recreational areas.

None of the miscellaneous land types mapped in the reconnaissance survey are included in tables 2 and 3, and not all of the high- and medium-intensity surveys are included. Reliable estimates and interpretations of the engineering properties of these land types cannot be given, because features are variable and only limited investigations and observations have been made.

With the use of the soil map for identification, the engineering interpretations reported here can be useful for many purposes. It should be emphasized that they do not eliminate the need for sampling and testing at the site of specific engineering works involving heavy loads or excavations deeper than the depths of layers here reported. Even in these situations, the soil map is useful for planning more detailed field investigations and for suggesting the kinds of problems that may be expected. In any given mapping unit, there may be inclusions of other soils or land types that are too small to delineate on the map or that are not within the objective of the survey. These inclusions may account for variations that affect engineering practices in such places.

Some of the terms used in this publication have a special meaning to soil scientists and a different meaning to engineers. The Glossary defines many such terms as they are used in soil science.

Engineering classification systems

The two systems most commonly used in classifying samples of soil horizons for engineering purposes are the system used by the American Association of State Highway Officials (AASHO) (*2*) and the Unified system developed by the Waterways Experiment Station, Corps of Engineers, and now used by the United States Department of Defense (*18*).

No AASHO classification is shown in table 2 for soils of the area surveyed, because the AASHO system has limited value in classification of Hawaiian soils. Most soils of this area are fine grained and fall within AASHO groups A–6 or A–7. Hawaiian soils classified in these groups do not exhibit the engineering properties associated with these groups in soils of temperate regions.

In table 2 the soil materials are classified according to the Unified system. In this system, soil materials are identified as coarse grained (G or S), fine grained (M or C), and highly organic (O), and symbols are used to identify each group. For example, soils that consist primarily of fine-grained material, either plastic or nonplastic, are identified by the symbols ML or CL if the liquid limit is low and by MH or CH if the liquid limit is high. If the classification is borderline between two groups, the symbols for both groups are given, joined by a hyphen. An example of such a borderline classification is "ML–CL."

In this survey area, engineering properties of soils classified as ML, MH, and CL may be significantly different in properties normally associated with these groups in temperate regions. These soils exhibit a higher shear strength and lower shrink-swell volume change with change in moisture content. The difference in magnitude of these properties is apparently related to the very fine particle size, microstructure, and high aggregate stability.

Estimated properties

Table 2 provides estimates of soil properties important in engineering uses. The estimates are based on field classification and descriptions, physical and chemical tests of selected representative samples, test data from comparable soils in adjacent areas, and on detailed experience in working with the individual kind of soil in the survey area.

The profile is described by soil layers that have significantly different engineering properties. The thickness of these layers and the depth from the surface are shown.

[4] HARLAN G. COLLINS, irrigation engineer, and HUGO T. SHOGREN, State conservation engineer, Soil Conservation Service, Honolulu, assisted in the preparation of this section.

TABLE 2.—*Estimated*

[Miscellaneous land types are not listed in this table, because the soil material is too

Soil series and map symbols	Depth to— Bedrock	Depth to— Seasonal high water table	Depth from surface	Classification: Dominant USDA texture
	Feet	*Feet*	*Inches*	
Alae: AaB, AcA, AcB	>5	>5	0–14	Cobbly sandy loam or sandy loam
			14–55	Coarse sand
Alaeloa: AeB, AeC, ALF, AME3, ANE, AeE, ALE3.	>5	>5	0–58	Silty clay
Alakai: rAAE	>5	(1)	0–32	Muck
			32–51	Clay
Amalu: rAMD, rAOD	>5	(1)	8–0	Peat
For Olokui part of rAOD, see Olokui series.			0–8	Clay
			8–8¼	Ironstone sheet
			8¼–60	Saprolite
Dystrandepts	>5	>5	0–39	Silt loam and loam
Mapped only with Tropohumults.			39–65	Gravelly loam
Ewa: EaA, EaB, EaC, EmB, EsA, EsB, EtB, EwA, EwB, EwC, EcA, EcB, EmA.	>5	>5	0–60	Silty clay loam
Haiku: HaB, HaC, HbB, HbC	>5	>5	0–45	Clay
			45–66	Saprolite
Halawa: HID, HID3, HJE, HJF2	>5	>5	0–58	Silty clay
			58	Saprolite.
Haleiwa: HcB, HdC, HeA, HeB	>5	>5	0–65	Silty clay
Halii: HfB, HfC, HfD2, HfE2	>5	>5	0–60	Gravelly silty clay, silty clay loam, silty clay, and clay loam.
Haliimaile: HgB, HgC, HhB, HhC, HkC2	>5	>5	0–65	Silty clay, clay
Hamakuapoko: H1B, H1C, H1C2	>5	>5	0–51	Silty clay
Hana:				
HKLD, HKMD	3–4	>5	0–7	Very stony or extremely stony silty clay loam.
			7–34	Silty clay loam
			34	Cinders over lava.
HKNC, HKOC	1. 5–3. 0	>5	0–8	Silty clay; loam extremely stony in places
			8–20	Cobbly silty clay
			20	Lava.
Hanalei: HmA, HnA, HnB, HoB, HpA, HrB	>5	0–5	0–13	Silty clay; peaty in places
			13–36	Silty clay loam
Hanamaulu: HsB, HsC, HsD, HsE, HtE, HuE	>5	>5	0–72	Silty clay and silty clay loam
Helemano: HLMG	>5	>5	0–60	Silty clay
Hihimanu: HMMF	>5	>5	0–72	Silty clay
Holomua: HvA, HvB, HvB3, HvC, HvC3	>5	>5	0–66	Silt loam and silty clay loam
Honolua: HwC, HwD	>5	>5	0–70	Silty clay
Honomanu: rHOD, rHR	>5	>5	3–0	Peat
For Amalu part of rHR, see Amalu series.			0–37	Silty clay
			37–60	Cobbly loam

See footnotes at end of table.

properties

variable for reliable evaluations to be made. Dashed lines indicate data are not applicable]

Classification—Con.					Corrosivity	
Unified	Permeability	Available water capacity	Reaction	Shrink-swell potential	Uncoated steel	Concrete
	Inches per hour	*Inches per inch of soil*	*pH value*			
SM	2. 0–6. 3	0. 08–0. 12	6. 6–7. 3	Low	Low	Low.
GW	6. 3–20. 0	0. 06–0. 08	7. 9–8. 4	Low	Moderate	Low.
MH	2. 0–6. 3	0. 12–0. 14	5. 1–6. 0	Moderate	High	Moderate.
Pt	6. 3–20. 0	----------	3. 3–4. 0	(2)	High	High.
CH	0. 06–0. 20	----------	4. 0–4. 5	High	High	High.
Pt	6. 3–20. 0	----------	3. 9–4. 2	(2)	High	High.
OH	0. 06–0. 63	----------	4. 2–4. 5	Moderate	High	High.
----------	<0. 06	----------	----------	----------	----------	
MH	2. 0–6. 3	----------	4. 0–5. 0	Low	High	High.
MH	2. 0–6. 3	0. 14–0. 16	6. 1–7. 3	(2)	Moderate	Low.
SM or GM	2. 0–6. 3	0. 08–0. 10	6. 6–7. 3	Low	Low	Low.
ML or CL	0. 63–2. 0	0. 10–0. 12	6. 6–7. 3	Moderate	Low	Low.
MH	2. 0–6. 3	0. 11–0. 13	4. 5–5. 0	Low	High	High.
MH	2. 0–6. 3	0. 10–0. 12	4. 5–5. 0	Low	High	High.
MH	2. 0–6. 3	0. 12–0. 14	4. 5–5. 5	Moderate	High	High.
MH–CH	0. 63–2. 0	0. 13–0. 15	6. 1–7. 3	Moderate	Low	Low.
MH	2. 0–6. 3	0. 10–0. 12	4. 0–5. 0	Low	High	High.
ML–CL	2. 0–6. 3	0. 08–0. 11	5. 1–6. 0	Low	Moderate	Moderate.
MH	2. 0–6. 3	0. 12–0. 14	4. 0–5. 5	Moderate	High	High.
OH or MH	2. 0–6. 3	0. 10–0. 12	5. 1–5. 5	(2)	High	Moderate.
MH	2. 0–6. 3	0. 12–0. 14	5. 5–6. 5	(2)	High	Low.
MH	2. 0–6. 3	0. 08–0. 10	6. 1–6. 5	(2)	High	Low.
MH	2. 0–6. 3	0. 08–0. 10	6. 1–6. 5	(2)	High	Low.
MH	0. 63–2. 0	0. 16–0. 18	4. 5–6. 5	Moderate	High	Moderate.
MH	0. 63–2. 0	0. 16–0. 18	6. 1–7. 3	Moderate	High	Low.
MH	2. 0–6. 3	0. 13–0. 15	4. 0–5. 5	Low	High	High.
MH	2. 0–6. 3	0. 11–0. 13	6. 1–7. 3	Moderate	Low	Low.
MH	2. 0–6. 3	----------	4. 5–5. 0	Low	High	High.
ML	0. 63–2. 0	0. 12–0. 14	4. 5–7. 3	Low	Low	Low.
MH	2. 0–6. 3	0. 12–0. 14	5. 1–5. 5	Moderate	High	Moderate.
Pt	6. 3–20. 0	0. 20–0. 30	3. 8–4. 5	(2)	High	High.
OH	2. 0–6. 3	0. 16–0. 18	3. 7–4. 5	(2)	High	High.
MH	2. 0–6. 3	0. 06–0. 08	4. 0–4. 5	Low	High	High.

TABLE 2.—*Estimated*

Soil series and map symbols	Depth to— Bedrock	Depth to— Seasonal high water table	Depth from surface	Classification: Dominant USDA texture
	Feet	*Feet*	*Inches*	
Honouliuli: HxA, HxB	>5	>5	0–68	Clay
Hoolehua: HyB3, HzA, HzB, HzC, HzE	>5	>5	0–15	Silty clay
			15–64	Silty clay
Hulua: HNUD, HNUF	1–1½	(1)	0–16	Silty clay
			16–18	Ironstone sheet
			18–60	Clay loam
Hydrandepts: rHT. For Tropaquods part of rHT, see Tropaquods.	>5	>5	3–0	Peat
			0–37	Silty clay loam and silty clay
			37–60	Cobbly loam
Iao: IaA, IaB, IbB, IbC, IcB, IcC	>5	>5	0–60	Clay or silty clay; cobbly in places
Io: ISD	>5	>5	0–30	Silty loam, silty clay loam, and clay loam
			30–39	Cinders
			39–45	Loam
Ioleau: IoB, IoC, IoD2, IoE2	>5	>5	0–61	Silty clay loam and silty clay
Jaucas:				
JaC, JfB, JkB, JL	>5	>5	0–60	Sand
JcC	>5	2–5	0–60	Sand
Kaena: KaB, KaC, KaeD, KanE, KavB, KavC, KaeB, KaeC.	>5	(3)	0–54	Stony clay
Kahana: KbB, KbC, KbD	>5	>5	0–61	Silty clay
Kahanui: KASD, KATD	>5	>5	0–30	Silty clay, clay, and ironstone fragments
			30–60	Saprolite
Kailua: KBID	3.5–5	>5	0–40	Silty clay and silty clay loam
Kaimu: KCXD	2–5	>5	0–8	Extremely stony peat
			8–20	Aa lava.
Kaipoioi: KDIE, KDVE	>5	>5	0–61	Loam, silt loam, and silty clay loam
Kalae: KcB, KcC, KcC3, KcD3, KcE3	>5	>5	0–41	Silty clay
			41–67	Silt loam
Kalapa: KdD, KdE, KdF, KEHF	>5	>5	0–60	Silty clay or clay
Kalaupapa: KFID	½–1½	>5	0–14	Silty clay loam and silt loam
			14	Pahoehoe lava.
Kalihi: Ke	>5	2–5	0–70	Clay
Kaloko: Kf, Kfa, Kfb	>5	1–2	0–60	Clay and silty clay
Kamaole: KGKC, KGLC	1½–2	>5	0–20	Silty clay loam and very stony silty clay
			20	Aa lava.
Kaneohe: KgB, KgC, KHMC, KHME, KHMF, KHOF.	>5	>5	0–60	Silty clay or silty clay loam
Kanepuu: KhB, KhB2, KhC, KhC2	>5	>5	0–61	Silty clay
Kapaa: KkB, KkC, KkD, KkE, KG	>5	>5	0–60	Silty clay and clay loam
Kapuhikani: KKTC	1½–3	>5	0–20	Extremely stony clay and clay
			20–27	Soft weathered rock
			27	Bedrock.

See footnotes at end of table.

properties—Continued

Classification—Con.	Permeability	Available water capacity	Reaction	Shrink-swell potential	Corrosivity	
Unified					Uncoated steel	Concrete
	Inches per hour	*Inches per inch of soil*	*pH value*			
CL	0. 20–0. 63	0. 14–0. 16	6. 6–7. 8	High	Low	Low.
MH	0. 63–2. 0	0. 14–0. 16	3. 8–4. 5	Moderate	High	High.
MH	0. 63–2. 0	0. 15–0. 17	6. 1–6. 5	Low	Low	Low.
OH	2. 0–6. 3	0. 12–0. 14	5. 1–5. 5	(2)	High	Moderate.
	<0. 06					
MH	2. 0–6. 3	0. 12–0. 14	4. 5–5. 0	Low	High	High.
Pt	6. 3–20. 0	0. 20–0. 30	3. 8–4. 5	(2)	High	High.
OH	2. 0–6. 3	0. 16–0. 18	3. 7–4. 5	(2)	High	High.
MH	2. 0–6. 3	0. 06–0. 08	4. 0–4. 5	Low	High	High.
CL	0. 20–0. 63	0. 13–0. 15	6. 6–7. 3	Moderate	Low	Low.
MH	2. 0–6. 3	0. 15–0. 17	6. 6–7. 8	Low	Low	Low.
	2. 0–6. 3		7. 9–8. 4	Low	Low	Low.
ML	2. 0–6. 3	0. 15–0. 17	7. 9–8. 4	Low	Low	Low.
MH	0. 06–0. 63	0. 12–0. 14	4. 0–5. 0	Moderate	High	High.
SP	6. 3–20. 0	0. 05–0. 07	6. 6–7. 8	Low	Low	Low.
SP	6. 3–20. 0	0. 05–0. 07	7. 9–8. 4	Low	High	High.
CH	0. 06–0. 63	0. 11–0. 13	6. 6–7. 3	High	Low	Low.
MH	2. 0–6. 3	0. 10–0. 12	4. 5–7. 3	Moderate to low	Moderate to low	Moderate to low.
MH	2. 0–6. 3	0. 10–0. 12	4. 5–5. 0	Moderate	High	High.
ML or MH	2. 0–6. 3	0. 10–0. 12	4. 5–5. 0	Low	High	High.
OH or MH	2. 0–6. 3	0. 19–0. 21	4. 5–6. 0	(2)	High	High.
Pt	>20. 0	0. 10–0. 15	6. 6–7. 3	Moderate	Low	Low.
OH or MH	2. 0–6. 3	0. 13–0. 15	6. 6–7. 8	Moderate	Low	Low.
MH	2. 0–6. 3	0. 12–0. 14	5. 1–5. 5	Moderate	High	Moderate.
ML	2. 0–6. 3	0. 12–0. 14	5. 1–5. 5	Low	High	Moderate.
MH	2. 0–6. 3	0. 12–0. 14	4. 5–5. 0	Moderate	High	High.
ML	0. 63–2. 0	0. 19–0. 21	6. 6–7. 3	Low	Low	Low.
CH	0. 06–0. 20	0. 12–0. 14	6. 1–7. 3	High	High	Low.
CH	0. 06–0. 63	0. 12–0. 14	6. 1–7. 8	High	High	Moderate.
MH–CH	0. 63–2. 0	0. 09–0. 11	6. 1–7. 8	Low	Low	Low.
MH	2. 0–6. 3	0. 11–0. 13	5. 1–6. 5	Moderate	High	Moderate.
ML–MH	0. 63–2. 0	0. 11–0. 13	6. 1–7. 3	Moderate	Low	Low.
MH	2. 0–6. 3	0. 13–0. 15	4. 5–6. 0	Low	High	Moderate.
CH	0. 06–0. 20	0. 11–0. 13	7. 4–7. 8	High	Low	Low.
ML	0. 06 0. 20	0. 05–0. 07	7. 9–8. 4	Low	Low	Low.

TABLE 2.—*Estimated*

Soil series and map symbols	Depth to—		Depth from surface	Classification
	Bedrock	Seasonal high water table		Dominant USDA texture
	Feet	*Feet*	*Inches*	
Kaupo: KLUD, KLVD	1½–3½	>5	0–27 27	Very stony silty clay loam; extremely stony in places. Aa lava.
Kawaihapai: KIA, KIB, KIC, KlaA, KlaB, KlbC, KlcB.	>5	>5	0–22 22–54	Clay loam; stony or very stony in places. Sandy loam.
Keaau: KmA, KmaB, KmbA	>5	1½–3	0–34 34–39 39–57	Clay and silty clay. Consolidated coral sand. Sand.
Keahua: KnB, KnC, KnaB, KnaC, KnaD, KnbD, KncC, KnhC, KnsC.	>5	>5	0–62	Silty clay loam and clay loam; cobbly or very stony in places.
Kealia: KMW	>5	1–3½	0–63	Silt loam, loam, and fine sandy loam.
Keawakapu: KNXD	>5	>5	0–9 9–18 18	Extremely stony silty clay loam. Silty clay. Aa lava.
Kekaha: KoA, KoB, KobA, KOYE	>5	>5	0–70	Silty clay or clay; extremely stony in places.
Kemoo: KpB, KpC, KpD, KpE, KpF, KPZ	>5	>5	0–66	Silty clay.
Koele: KrB, KrC, KrD, KRL, KRX	>5	>5	0–33 33–55	Silty clay loam. Stratified clay loam, silt loam, and sandy loam.
Kokee: KSKE, KSKF	>5	>5	0–42 42	Silty clay loam and silty clay. Saprolite.
Koko: KsB, KsC, KsD	>5	>5	0–48 48	Silt loam and clay loam. Cinders and tuff.
Kokokahi: KtC, KTKE	>5	(3)	0–44	Clay or very stony clay.
Kolekole: KuB, KuC, KuD	>5	>5	0–38 38–60	Silty clay loam. Silty clay loam; brittle pan.
Koloa: KvB, KvC, KvD	1½–3½	>5	0–20 20	Stony silty clay. Bedrock.
Kolokolo: Kw, KUL	>5	>5	0–60	Silty clay loam and loam.
Koolau: KVSB, KVSE	>5	2–4	0–32 32–60	Silty clay. Clay loam with ironstone bands.
Kula: KxC, KxD, KxaD, KxbE	2–5	>5	0–54 54	Loam, silt loam, and silty clay loam. Bedrock.
Kunia: KyA, KyB, KyC	>5	>5	0–47 47–74	Silty clay. Silty clay loam.
Kunuweia: KZC	>5	>5	0–12 12–60	Very gravelly clay loam. Hard and soft plinthite.
Lahaina: LaA, LaB, LaB3, LaC, LaC3, LaD, LaD3, LaE3.	>5	>5	0–31 31–60	Silty clay. Silty clay loam.
Laumaia: LME, LMF, LNE	3½–5	>5	0–42 42–51 51	Silty clay loam and silt loam. Cemented ash and cinders. Stratified silt loam and cinders.

See footnotes at end of table.

properties—Continued

Classification—Con.	Permeability	Available water capacity	Reaction	Shrink-swell potential	Corrosivity	
Unified					Uncoated steel	Concrete
	Inches per hour	*Inches per inch of soil*	*pH value*			
CL	2.0–6.3	0.10–0.12	6.1–7.3	Low	Low	Low.
CL	0.63–2.0	0.08–0.15	6.6–7.3	Moderate	Low	Low.
SM	2.0–6.3	0.12–0.14	6.6–7.3	Low	Low	Low.
CH	0.06–0.20	0.12–0.14	7.4–7.8	High	High	Low.
----------	<0.06	----------	----------	----------	----------	
SP	6.3–20.0	----------	7.9–8.4	Low	High	Low.
ML-CL	0.63–2.0	0.06–0.12	6.1–7.3	Low	Low	Low.
ML or SM	2.0–6.3	0.09–0.11	7.4–8.4	Low	High	High.
ML	0.63–2.0	0.10–0.12	6.6–7.3	Low	Low	Low.
ML–CL	0.63–2.0	0.14–0.16	6.6–7.3	Moderate	Low	Low.
MH	0.63–2.0	0.15–0.17	7.4–7.8	Moderate	Moderate	Low.
MH	0.63–6.3	0.10–0.12	6.1–7.3	Moderate	Moderate	Low.
ML	2.0–6.3	0.13–0.15	4.5–6.0	Moderate	Moderate	Moderate.
CL, ML or SM	2.0–6.3	0.12–0.14	5.6–6.5	Low	Moderate	Moderate.
MH	2.0–6.3	0.15–0.17	4.5–5.0	Moderate	High	High.
MH	2.0–6.3	----------	4.5–5.0	Low	High	High.
ML	0.63–2.0	0.16–0.18	6.6–7.3	Low	Low	Low.
CH	0.06–0.63	0.12–0.14	6.1–7.4	High	High	Low.
ML	2.0–6.3	0.09–0.11	4.0–5.5	Moderate	High	High.
ML	0.63–2.0	0.10–0.12	4.5–6.0	Low	High	High.
ML-MH	2.0–6.3	0.10–0.12	6.1–7.3	Moderate	Low	Low.
MH	0.63–2.0	0.12–0.14	6.6–7.3	Moderate	High	Low.
MH-OH	6.3–20.0	0.12–0.14	4.0–5.0	Moderate	High	High.
MH	0.2–0.63	0.12–0.14	4.5–5.0	Low	High	High.
ML	2.0–6.3	0.14–0.16	6.1–7.3	Low	Low	Low.
ML-MH	0.63–2.0	0.12–0.14	4.0–6.5	Moderate	Moderate	High.
ML	0.63–2.0	0.14–0.16	5.6–6.0	Low	Low	Moderate.
GC	2.0–6.3	----------	4.5–5.0	Low	High	High.
MH	2.0–6.3	----------	4.5–5.0	Low	High	High.
CL-ML	0.63–2.0	0.10–0.12	5.6–6.5	Moderate	Low	Moderate.
ML	0.63–2.0	0.11–0.13	5.6–6.5	Low	Low	Low.
MH-OH	2.0–6.3	0.15–0.17	6.6–7.8	Moderate	Low	Low.
----------	<0.06	----------	----------	----------	----------	
----------	----------	----------	----------	Low	Low	Low.

TABLE 2.—*Estimated*

Soil series and map symbols	Depth to—		Depth from surface	Classification
	Bedrock	Seasonal high water table		Dominant USDA texture
	Feet	*Feet*	*Inches*	
Lawai: LcB, LcC, LcD	>5	(3)	0–60	Silty clay
Leilehua: LeB, LeC	>5	>5	0–75	Silty clay and clay
Lihue: LhB, LhC, LhD, LhE2, LIB, LIC	>5	>5	0–60	Silty clay; gravelly in places
Lolekaa: LoB, LoC, LoD, LoE, LoF	>5	>5	0–42 42–65	Silty clay Loam
Lualualei: LuA, LuB, LvA, LvB, LPE	>5	>5	0–60	Clay
Mahana: MaC, MaD, MaD3, MaE, MaE3, McC2, McD2, McE2, MBL.	>5	>5	0–61	Silt loam and silty clay loam
Makaalae: MID, MJD, MWE	2–4	>5	0–40 40	Clay and silty clay Aa lava.
Makalapa: MdB, MdC, MdD	1½–3½	>5	0–38 38	Clay Volcanic tuff.
Makapili: MeB, MeC, MeD, MeE	>5	>5	0–60	Silty clay and clay loam
Makawao: MfB, MfC	>5	>5	0–60	Silty clay
Makaweli: MgB, MgC, MgD, MgE2, MhB, MhC, MhD, MhE.	>5	>5	0–60	Silty clay loam and silt loam
Makena: MXC	3½–5	>5	0–44 44	Silt loam Aa lava.
Makiki: MkA, MIA	1½–5	>5	0–54	Clay loam; stony in places
Mala: MmA, MmB	>5	>5	0–40 40–60	Silty clay Coral sand
Malama: MYD	1½–2½	>5	0–8 8–28 28	Extremely stony muck Aa lava and muck Aa lava.
Mamala: MnC	1–1½	>5	0–19 19	Silty clay loam Hard coral.
Manana: MoB, MoC, MoD2, MpB, MpC, MpD, MpD2, MpE.	>5	>5	0–15 15–15¼ 15¼–60	Silty clay loam and silty clay Pan Silty clay
Mokuleia:				
Mr, Ms, Mt, Mtb	>5	>5	0–16 16–50	Clay loam, loam, or fine sandy loam Sand
Mta	>5	2–4	0–15 15	Clay and clay loam Sand
Molokai: MuA, MuB, MuB3, MuC, MuC3, MuD, MvD3.	>5	>5	0–72	Silty clay loam
Naiwa: NAC, NAC3	3–5	>5	0–52 52–60	Silty clay loam, silt loam, and loam Saprolite
Niu: NcC, NcD, NcD2, NcE2	>5	>5	0–60	Silty clay loam and silty clay
Niulii: NLE, NME	3–5	>5	0–40 40	Silty clay loam and silty clay Lava bedrock.

See footnotes at end of table.

properties—Continued

Classification—Con.	Permeability	Available water capacity	Reaction	Shrink-swell potential	Corrosivity	
Unified					Uncoated steel	Concrete
	Inches per hour	*Inches per inch of soil*	*pH value*			
MH	0.63–6.3	0.14–0.16	5.1–6.0	Moderate	High	Moderate.
MH–CH	2.0–6.3	0.10–0.12	4.0–4.5	Moderate	High	High.
MH	2.0–6.3	0.13–0.15	5.1–7.3	Moderate	Low	Moderate.
MH	2.0–6.3	0.10–0.12	4.0–5.5	Moderate	High	Moderate.
ML–MH	2.0–6.3	0.11–0.13	4.0–4.5	Low	High	High.
CH	0.06–0.20	0.11–0.13	5.6–7.3	High	Moderate	Low.
MH	2.0–6.3	0.11–0.13	5.6–6.5	Moderate	High	Moderate.
CH	0.63–2.0	----------	5.1–6.5	High	High	Moderate.
CH	0.06–0.20	0.11–0.13	7.4–8.4	High	Moderate	Low.
MH	2.0–6.3	0.12–0.14	4.5–5.5	Low	High	High.
MH	2.0–6.3	0.17–0.19	5.1–6.5	Moderate	High	Moderate.
ML	0.63–2.0	0.14–0.16	6.1–7.3	Low	Low	Low.
ML	2.0–6.3	0.17–0.19	7.4–8.4	Low	Low	Low.
MH	2.0–6.3	0.13–0.15	5.1–6.0	Moderate	Moderate	Moderate.
ML–MH	0.63–2.0	0.11–0.13	6.1–7.8	Moderate	Moderate	Low.
SP	6.3–20.0	0.06–0.08	7.4–7.8	Low	Moderate	Low.
Pt	<20.0	0.10–0.12	5.1–6.0	High shrink, low swell	High	Moderate.
----------	<20.0	----------	----------	----------	----------	
CL–ML	0.63–2.0	0.16–0.18	6.6–7.8	Low	Low	Low.
MH	2.0–6.3	0.09–0.11	4.5–5.0	Moderate	High	High.
----------	<0.06	----------	----------	----------	----------	
MH	0.63–2.0	0.10–0.12	4.0–5.0	Low	High	High.
CL or SM	0.63–6.3	0.10–0.16	6.6–7.3	Moderate to low	Moderate	Low.
SP	6.3–20.0	0.06–0.08	7.9–8.4	Low	Low	Low.
CH	0.06–0.20	0.12–0.14	7.4–7.8	High	Moderate	Low.
SP	6.3–20.0	0.06–0.08	7.4–7.8	Low	Low	Low.
ML	0.63–2.0	0.11–0.13	4.0–7.3	Low	Low	Low.
ML	2.0–6.3	0.09–0.11	4.5–5.5	Moderate	High	High.
MH	----------	----------	----------	----------	----------	
ML CL	0.63–2.0	0.11–0.13	5.6–7.3	Moderate	Low	Low.
MH–OH	2.0–6.3	0.17–0.19	4.5–5.0	Moderate	High	High.

TABLE 2.—*Estimated*

Soil series and map symbols	Depth to— Bedrock	Depth to— Seasonal high water table	Depth from surface	Classification: Dominant USDA texture
	Feet	*Feet*	*Inches*	
Nohili: Nh	>5	1½–3	0–120	Clay
Nonopahu: NnC, NoC	>5	>5	0–65	Clay and silty clay
Oanapuka: OAD, OED	3½–5	>5	0–46 46–55	Very stony silt loam and loam Aa lava.
Olelo: OFC	>5	>5	0–37 37–60	Silty clay Saprolite
Oli: OID, OMB, OME, OMF	2–4	>5	0–30 30	Silt loam Bedrock.
Olinda: ONC, OND, ONE	3–5	>5	0–36 36	Silty clay loam Bedrock.
Olokui: OOE	>5	(1)	4–0 0–11 11–11½ 11½–60	Organic matter Silty clay loam Ironstone sheet Saprolite
Opihikao: OPD	<1	>5	0–5 >5	Muck Bedrock.
Paaiki: PGE, PGF	3–5	>5	0–40 40–50	Silty clay loam and silty clay Saprolite.
Paaloa: PaC, PbC	>5	>5	0–60	Silty clay and clay
Paia: PcB, PcC, PcC2	>5	>5	0–60	Silty clay and clay
Pakala: PdA, PdC, PHXC	>5	>5	0–60	Stratified clay loam, very fine sandy loam, silt loam, and silty clay loam; extremely stony in places.
Pamoa: PID, PID2, PJD2	>5	>5	0–62	Silty clay and clay
Pane: PXD	>5	>5	0–39 39–65	Silt loam and loam Gravelly loam
Papaa: PYD, PYE, PYF	3½–5	>5	0–28 28–40 40	Clay Silty clay loam Basalt.
Paumalu: PeB, PeC, PeD, PeE, PeF, PZ	>5	>5	0–48 48–70	Silty clay Gravelly silty clay
Pauwela: PfB, PfC, PfD	>5	>5	0–54	Clay and silty clay
Pearl Harbor: Ph	>5	1–4	0–31 31–48	Clay Muck
Pohakupu: PkB, PkC	>5	>5	0–76	Silty clay loam
Pooku: PlB, PlD, PmB, PmC, PmD, PmE	>5	>5	0–62	Silty clay and silty clay loam
Puhi: PnA, PnB, PnC, PnD, PnE	>5	>5	0–60	Silty clay loam and silty clay
Pulehu: PoB, PoaB, PpA, PpB, PrA, PrB, PsA, PtA, PtB, PuB, PvC.	>5	>5	0–60	Stratified clay loam, loam, loamy sand, fine sandy loam, and silt loam; cobbly or stony in places.
Puuone: PZUE	1½–3½	>5	0–20 20–40	Sand Cemented sand

See footnotes at end of table

properties—Continued

Classification—Con.	Permeability	Available water capacity	Reaction	Shrink-swell potential	Corrosivity	
Unified					Uncoated steel	Concrete
	Inches per hour	*Inches per inch of soil*	*pH value*			
CH	0. 20–0. 63	0. 12–0. 14	4. 5–7. 8	High	High	Moderate.
CH	0. 20–0. 63	0. 10–0. 12	7. 4–7. 8	High	Moderate	Low.
ML	2. 0–6. 3	0. 08–0. 10	6. 6–7. 8	Low	Low	Low.
MH	2. 0–6. 3	0. 10–0. 12	4. 5–5. 0	Moderate	High	High.
MH	2. 0–6. 3			Low		
MH–ML	2. 0–6. 3	0. 12–0. 14	4. 5–6. 5	Low	High	High.
MH–OH	2. 0–6. 3	0. 13–0. 15	6. 1–6. 5	([2])	High	Low.
Pt	20. 0	0. 20–0. 30	4. 0–4. 5	([2])	High	High.
MH–OH	2. 0–6. 3	0. 12–0. 14	4. 0–5. 0	Moderate	High	High.
	<0. 06					
MH	0. 63–2. 0			Low	High	High.
Pt	6. 3–20. 0	0. 20–0. 30	5. 1–6. 5	High	High	Moderate.
MH	2. 0–6. 3	0. 17–0. 19	4. 5–6. 0	Moderate	High	Moderate.
MH	2. 0–6. 3	0. 10–0. 12	4. 5–5. 5	Low	High	High.
MH	0. 63–2. 0	0. 13–0. 15	7. 4–7. 8	Low	Low	Low.
CL and ML	0. 63–2. 0	0. 08–0. 14	4. 5–6. 0	Low	Low	Moderate.
CL	0. 20–0. 63	0. 09–0. 11	4. 5–7. 3	High	Low to moderate	Low to moderate.
MH	2. 0–6. 3	0. 14–0. 16	6. 1–7. 3	Moderate	Moderate	Low.
SM or GM	2. 0–6. 3	0. 08–0. 10	6. 6–7. 3	Low	Low	Low.
CH	0. 06–0. 20	0. 10–0. 12	6. 1–6. 5	High	Moderate	Low.
CL	0. 20–0. 63	0. 11–0. 13	6. 1–6. 5	Moderate	Moderate	Low.
MH	2. 0–6. 3	0. 10–0. 12	4. 5–6. 0	Moderate	High	High.
CL	2. 0–6. 3	0. 07–0. 09	5. 5–6. 0	Low	High	Moderate.
MH	2. 0–6. 3	0. 10–0. 12	4. 0–5. 0	Low	High	High.
CH	<0. 06	0. 10–0. 12	6. 6–8. 4	High	High	High.
Pt	<0. 06	0. 16–0. 18	7. 4–7. 8	High	High	High.
MH	2. 0–6. 3	0. 12–0. 14	6. 1–6. 5	Moderate	Moderate	Low.
MH	2. 0–6. 3		4. 0–6. 0	Low	High	High.
MH	2. 0–6. 3	0. 10–0. 12	4. 5–6. 5	Moderate to low	High	Moderate.
CL, SM or ML	0. 63–2. 0	0. 09–0. 13	6. 6–7. 8	Moderate to low	Low	Low.
SP	6. 3–20. 0	0. 06–0. 08	7. 9–8. 4	Low	Low	Low.
	<0. 06					

TABLE 2.—*Estimated*

Soil series and map symbols	Depth to— Bedrock	Depth to— Seasonal high water table	Depth from surface	Classification: Dominant USDA texture
	Feet	*Feet*	*Inches*	
Puu Opae: PwC, PwD, PwE	>5	>5	0–61	Silty clay loam and silty clay
Puu Pa: PZVE	1½–4	>5	0–47	Very stony silt loam
			47	Aa lava.
Tantalus: TAE, TAF, TCC, TCE	1–3	>5	0–29	Silty clay loam, silt loam, and very fine sandy loam.
			29	Cinders.
Tropaquods: rTO	>5	(1)	8–0	Peat
			0–11	Clay and silty clay loam
			11–11½	Ironstone sheet
			11½–60	Saprolite.
Tropohumults: rTP For Dystrandepts part of rTP, see Dystrandepts.	>5	>5	0–58	Silty clay
			58	Saprolite.
Ulupalakua: ULD	2–3½	>5	0–33	Silt loam and clay loam
			33	Cinders.
Uma: UME, UMF, URD	½–1	>5	0–6	Loamy coarse sand
			6–55	Cinders.
Uwala: UwB, UwC, UwC3	3–7	>5	0–60	Silty clay loam
Wahiawa: WaA, WaB, WaC, WaD2	>5	>5	0–60	Silty clay
Wahikuli: WbB, WcB, WcC, WdB	1½–3½	>5	0–32	Silty clay
			32	Bedrock.
Waiakoa: WeB, WeC, WfB, WgB, WgC, WhB, WhC, WlD2.	1½–3½	>5	0–33	Silty clay loam; cobbly or stony in places.
			33	Bedrock.
Waialeale: rWAF	1–2	(1)	3–0	Mucky peat
			0–21	Silty clay loam
			21	Saprolite.
Waialua: WkA, WkB, WlB, WlE, WmD, WnB	>5	>5	0–55	Silty clay
Waiawa: WJF	½–1½	>5	0–14	Clay
			14	Bedrock.
Waihuna: WoA, WoB, WoC, WoD, WohB	>5	>5	0–65	Clay and silty clay
Waikane: WpB, WpC, WpE, WpF, WpF2, WpaE.	>5	>5	0–60	Silty clay
Waikapu: WrA, WrB, WrB3, WrC3	>5	>5	0–60	Silty clay loam
Waikomo: Ws, Wt, Wu	1–1½	>5	0–20	Stony silty clay and silty clay loam
			20	Bedrock.
Wailuku: WvB, WvC, WwC	>5	>5	0–60	Silty clay
Wainee: WxB, WxC, WyB, WyC	>5	>5	0–56	Extremely stony silty clay
Waipahu: WzA, WzB, WzC	>5	>5	0–70	Silty clay

[1] Soil is always wet.
[2] High shrink potential; low swell potential.
[3] Seep areas.

properties—Continued

Classification—Con. Unified	Permeability	Available water capacity	Reaction	Shrink-swell potential	Corrosivity Uncoated steel	Corrosivity Concrete
	Inches per hour	*Inches per inch of soil*	*pH value*			
ML-MH	2.0-6.3	0.12-0.14	4.5-6.0	Low	High	Moderate.
ML	2.0-6.3	0.05-0.07	5.6-7.3	Low	Low	Low.
MH-OH	2.0-6.3	----------	6.1-7.3	(2)	Moderate	Low.
Pt	6.3-20.0	0.20-0.30	3.9-4.5	(2)	High	High.
OH or MH-OH	0.06-6.3	0.13-0.14	4.0-5.0	Moderate	High	High.
----------	<0.06	----------	----------	----------	----------	
MH	0.63-6.3	----------	4.0-5.0	Low	High	High.
MH	2.0-6.3	0.12-0.14	4.5-5.5	Moderate	High	High.
MH-OH	2.0-6.3	0.17-0.19	6.1-7.8	Moderate	Moderate	Low.
SM	>20.0	0.07-0.10	7.4-7.8	Low	Low	Low.
ML	0.63-2.0	0.10-0.12	4.5-6.0	Low	Low	Moderate to high.
MH	2.0-6.3	0.11-0.13	5.6-7.3	Low	Low	Moderate to low.
ML-CL	0.63-2.0	0.12-0.14	7.4-7.8	Low	Low	Low.
ML-CL	0.63-2.0	0.08-0.15	6.1-7.3	Low	Low	Low.
Pt	6.3-20.0	0.20-0.30	3.0-3.5	High	High	High.
MH-OH MH	2.0-6.3	0.12-0.14	4.0-4.5	Moderate	High	High.
	----------	----------	----------	----------	----------	
MH-CH	0.63-2.0	0.13-0.15	6.1-7.3	Moderate	Moderate	Low.
CH	0.20-2.0	0.15-0.17	6.1-7.3	High	Moderate	Low.
CH	0.20-0.63	0.09-0.11	5.1-7.3	High	Moderate	Moderate.
MH	2.0-6.3	0.10-0.12	4.5-4.0	Low	High	High.
ML	0.63-2.0	0.12-0.14	5.1-7.3	Low	Low	Low.
MH	0.63-2.0	0.09-0.11	6.6-7.8	Low	Low	Low.
MH	0.63-2.0	0.13-0.15	5.6-6.5	Low	Low	Low.
ML-CL	2.0-6.3	0.05-0.07	6.6-7.3	Low	Low	Low.
CL	0.20-2.0	0.11-0.13	6.1-6.5	High	Low	Low.

TABLE 3.—*Engineering*

[Most of the miscellaneous land types are not listed

Soil series and map symbols	Suitability as a source of—		Soil features affecting—		
	Topsoil	Road fill	Highway location	Farm ponds	
				Reservoir areas	Embankments
Alae: AaB, AcA, AcB	Surface 14 inches is good; 14 to 55 inches is poor.	Good if soil binder is added.	Subject to flooding in winter.	Coarse and very coarse sand below a depth of 14 inches.	Sandy material; highly pervious material.
Alaeloa: AeB, AeC, AeE, ALE3, ALF, AME3, ANE.	Good	Good	Slopes as much as 70 percent.	Slopes as much as 70 percent; moderately rapid permeability.	Slopes as much as 70 percent.
Alakai: rAAE	Poor: always wet.	Poor: organic material; always wet.	Organic material; wetness.	Wetness; organic material; pervious material.	(2)
Amalu: rAMD, rAOD. For Olokui part of rAOD, see Olokui series.	Poor: peat and clay; always wet.	Poor: organic material; always wet; accessibility is difficult.	Organic material; wetness.	Wetness; organic material; pervious material.	(2)
Badland: BL, BM. For Mahana part of BM, see Mahana series.	Fair: very low fertility.	Good	Slopes as much as 70 percent.	Slopes as much as 70 percent.	Erodible: slopes as much as 70 percent.
Blown-out land: BW	Fair: low fertility.	Good	Erodible where embankments are exposed.	Moderate permeability.	Erodible: high compacted density.
Ewa:					
EaA, EaB, EaC, EmA, EmB, EsA, EsB.	Good	Good	(3)	Moderate permeability.	(3)
EcA, EcB, EtB, EwA, EwB, EwC.	Good, except cobbly or stony.	Good, except cobbly or stony.	(3)	Moderate permeability.	All features favorable, except cobbly or stony.
Haiku: HaB, HaC, HbB, HbC.	Fair to a depth of 30 inches: clayey; low fertility.	Good	(3)	Moderately rapid permeability.	(4)
Halawa: HID, HID3, HJE, HJF2.	Good	Good	Slopes as much as 70 percent.	Slopes as much as 70 percent; moderately rapid permeability.	Slopes as much as 70 percent.
Haleiwa:					
HcB, HeA, HeB	Good	Good	Subject to localized flooding.	Moderate permeability.	(3)
HdC	Good, except stony.	Good, except stony.	(3)	Moderate permeability.	All features favorable, except stoniness.

See footnotes at end of table.

interpretations

in this table, because the soil material is too variable]

Soil features affecting—Continued					Degree and kind of limitations for septic tank filter fields
Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	Foundations for low buildings [1]	
(2)	Low available water capacity; high water intake rate.	Sandy substratum; rapid permeability.	Sandy substratum; excessively drained; low available water capacity.	Low shrink-swell potential; low compressibility; coarse texture; rapid permeability.	Slight: rapid permeability.
(2)	Moderate to severe erosion hazard on steep slopes.	Slopes as much as 70 percent.	Slopes as much as 70 percent.	Slopes as much as 70 percent.	Slight on slopes of 3 to 7 percent; moderate on slopes of 7 to 15 percent; severe on slopes of more than 15 percent.
Very poorly drained.	(3)	(2)	(2)	High compressibility; organic soil; wetness.	Severe: always wet.
Poorly drained	(3)	(2)	(2)	High compressibility; wetness; organic material.	Severe: always wet.
(2)	Highly erodible; slopes as much as 70 percent.	Slopes as much as 70 percent; erodible.	Slopes as much as 70 percent; difficult to establish plants.	Slopes as much as 70 percent.	Severe: slopes generally more than 10 percent.
(2)	Slow intake rate	Susceptible to siltation.	Low fertility; difficult to establish plants.	(3)	Slight: moderate permeability.
(2)	(3)	(3)	Difficult to establish plants unless irrigated.	(3)	Slight: moderate permeability; severe where soil is moderately shallow.
(2)	All features favorable, except cobbly or stony.	All features favorable, except cobbly or stony.	Difficult to establish plants unless irrigated; cobbly or stony.	(3)	Slight: moderate permeability.
(2)	(3)	Clayey; moderately rapid permeability.	Clayey; slopes as much as 15 percent.	Slopes as much as 15 percent.	Slight on slopes of not more than 7 percent; moderate on slopes of 7 to 15 percent.
(2)	Slopes as much as 70 percent.	All features favorable where slopes are not more than 20 percent.	Slopes as much as 70 percent.	Slopes as much as 70 percent.	Slight on slopes of 3 to 7 percent; moderate on slopes of 7 to 15 percent; severe on slopes of more than 15 percent.
(2)	(3)	(3)	(3)	(3)	Slight, except where subject to local flooding.
(2)	All features favorable, except stoniness.	Stoniness	Stoniness	Stoniness	Slight: stoniness.

TABLE 3.—*Engineering*

Soil series and map symbols	Suitability as a source of—		Soil features affecting—		
	Topsoil	Road fill	Highway location	Farm ponds	
				Reservoir areas	Embankments
Halii: HfB, HfC, HfD2, HfE2.	Poor: low fertility.	Good	Slopes as much as 40 percent.	Moderately rapid permeability; slopes as much as 40 percent.	(4)
Haliimaile: HgB, HgC, HhB, HhC, HkC2.	Good to a depth of 40 inches; fair from 40 to 60 inches; very sticky.	Good	(3)	Moderately rapid permeability.	(3)
Hamakuapoko: HlB, HlC, HlC2.	Fair: very sticky and very plastic; low fertility.	Good	(3)	Moderately rapid permeability.	Very sticky and very plastic.
Hana: HKNC, HKOC	Fair: dehydrates irreversibly; low fertility.	Poor: poor workability; low compacted density; thixotropic.	Slopes as much as 15 percent; high compressibility; low bearing capacity.	Moderately rapid permeability; slopes as much as 15 percent; cinders at a depth of 1½ to 3 feet.	High seepage rate; low compacted density; high compressibility; poor workability.
HKLD	Fair: dehydrates irreversibly; low fertility; stony.	Poor: poor workability; low compacted density; thixotropic; stony.	Slopes as much as 25 percent; high compressibility; low bearing capacity; stoniness.	Moderately rapid permeability; slopes as much as 25 percent; cinders at a depth of 3 to 4 feet; stoniness.	High seepage rate; low compacted density; high compressibility; poor workability; stoniness.
HKMD	Fair: dehydrates irreversibly; low fertility; stony.	Poor: poor workability; low compacted density; thixotropic; stony.	Slopes as much as 25 percent; high compressibility; low bearing capacity; stoniness.	Moderately rapid permeability; slopes as much as 25 percent; cinders at a depth of 1½ to 4 feet; stoniness.	High seepage rate; low compacted density; high compressibility; poor workability; stoniness.
Hanalei: HmA, HnA, HnB, HoB, HpA, HrB.	Poor: always wet.	Poor: high water table; always wet.	High water table; subject to flooding.	High water table; subject to flooding.	Wetness; fair stability; subject to flooding.
Hanamaulu: HsB, HsC, HsD, HsE, HtE.	Fair: low fertility.	Good	Slopes as much as 40 percent.	Slopes as much as 40 percent; moderately rapid permeability.	Slopes as much as 40 percent. See also (4).
HuE	Fair: low fertility; bouldery.	Good, except bouldery.	Slopes as much as 35 percent; bouldery.	Slopes as much as 35 percent; moderately rapid permeability; bouldery.	Slopes as much as 35 percent; bouldery. See also (4).

See footnotes at end of table.

interpretations—Continued

Soil features affecting—Continued					
Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	Foundations for low buildings [1]	Degree and kind of limitations for septic tank filter fields
(2)	(2)	Low fertility; slopes as much as 40 percent.	Low fertility; slopes as much as 40 percent.	Slopes as much as 40 percent.	Slight on slopes of 3 to 8 percent; moderate on slopes of 8 to 15 percent; severe on slopes of more than 15 percent.
(2)	Slopes as much as 15 percent.	(3)	(3)	All features favorable, except slopes as much as 15 percent.	Slight on slopes of not more than 7 percent; moderate on slopes of as much as 15 percent.
(2)	Slopes as much as 15 percent.	Very sticky and very plastic.	Very sticky and very plastic.	Moderate shrink-swell potential; slopes as much as 15 percent.	Slight on slopes of 3 to 7 percent; moderate on slopes of 7 to 15 percent.
(2)	(2)	Poor workability	Poor workability	High shrinkage; low bearing capacity; high compressibility.	Slight on slopes of 3 to 7 percent; moderate on slopes of 7 to 15 percent.
(2)	(2)	Poor workability; stoniness.	Poor workability; stoniness.	High shrinkage; low bearing capacity; high compressibility; stoniness.	Slight on slopes of 3 to 7 percent; moderate on slopes of 7 to 15 percent; severe on slopes of more than 15 percent.
(2)	(2)	Poor workability; stoniness.	Poor workability; stoniness.	High shrinkage; low bearing capacity; high compressibility; stoniness.	Slight on slopes of 3 to 7 percent; moderate on slopes of 7 to 15 percent; severe on slopes of more than 15 percent.
High water table; moderate permeability; subject to flooding.	(3)	Wetness; high water table; subject to flooding.	High water table; wetness.	High water table; subject to flooding.	Severe: high water table; subject to flooding.
(2)	All features favorable, except slopes as much as 40 percent.	All features favorable, except slopes as much as 40 percent.	Slopes as much as 40 percent.	Slopes as much as 40 percent.	Slight on slopes of 3 to 8 percent; moderate on slopes of 8 to 15 percent; severe on slopes of more than 15 percent.
(2)	All features favorable, except slopes as much as 35 percent; bouldery.	All features favorable, except slopes as much as 35 percent; bouldery.	Slopes as much as 35 percent; bouldery.	Slopes as much as 35 percent; bouldery.	Severe: slopes generally more than 15 percent; bouldery.

TABLE 3.—*Engineering*

Soil series and map symbols	Suitability as a source of—		Soil features affecting—		
	Topsoil	Road fill	Highway location	Farm ponds: Reservoir areas	Farm ponds: Embankments
Helemano: HLMG	Fair: 30 to 90 percent slopes.	Fair: 30 to 90 percent slopes.	Slopes of 30 to 90 percent.	Moderately rapid permeability; 30 to 90 percent slopes.	Slopes of 30 to 90 percent.
Hihimanu: HMMF	Fair: slopes of 40 to 70 percent; low fertility.	Fair: slopes of 40 to 70 percent.	Slopes of 40 to 70 percent.	Slopes of 40 to 70 percent; moderately rapid permeability.	Slopes of 40 to 70 percent. See also (4).
Holomua: HvA, HvB, HvB3, HvC, HvC3.	Good	Good	Bedrock as shallow as 4 feet in places.	Moderate permeability; bedrock as shallow as 4 feet in places.	Poor stability; piping hazard.
Honolua: HwC, HwD	Fair: low fertility.	Good	Slopes as much as 25 percent.	Moderately rapid permeability; slopes as much as 25 percent.	(4)
Honomanu: rHOD, rHR. For Amalu part of rHR, see Amalu series.	Fair: dehydrates irreversibly; low fertility.	Poor: poor workability; high compressibility; thixotropic; low compacted density.	High compressibility; low bearing capacity; slopes as much as 25 percent.	Moderately rapid permeability; slopes as much as 25 percent.	High seepage rate; high compressibility; thixotropic.
Honouliuli: HxA, HxB	Fair: very sticky and very plastic.	Poor: highly plastic; poor workability; high shrink-swell potential.	High shrink-swell potential; low shear strength.	Moderately slow permeability; high shrink-swell potential.	High shrink-swell potential; low shear strength.
Hoolehua: HyB3, HzA, HzB, HzC, HzE.	Good	Good	Slopes as much as 35 percent.	Moderate permeability; slopes as much as 35 percent.	High compacted density.
Hulua: HNUD, HNUF	Poor: always wet; low fertility.	Poor: poor workability; always wet.	Slopes as much as 70 percent; wetness; seepage.	Slopes as much as 70 percent; ironstone layer at a depth of about 15 inches.	Wetness; high organic-matter content to a depth of 15 inches; high compressibility.
Hydrandepts: rHT. For Tropaquods part of rHT, see Tropaquods.	Fair: dehydrates irreversibly; low fertility.	Poor: poor workability; high compressibility; low compacted density.	High compressibility; low bearing capacity; slopes as much as 25 percent.	Moderately rapid permeability; slopes as much as 25 percent.	High seepage rate; high compressibility.
Iao: IaA, IaB, IbB, IbC, IcB, IcC.	Fair: very sticky and very plastic.	Fair: moderate shrink-well potential.	Subject to local flooding.	Moderately slow permeability; moderate shrink-swell potential.	Moderate shrink-swell potential; clayey.
Io: ISD	Good to a depth of 20 inches; variable below 20 inches.	Fair: unstable material.	Slopes as much as 25 percent; unstable material.	Moderately rapid permeability; cinders at a depth of 20 to 40 inches; slopes as much as 25 percent.	Unstable material; high seepage rate; piping hazard.

See footnotes at end of table.

interpretations—Continued

Soil features affecting—Continued					Degree and kind of limitations for septic tank filter fields
Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	Foundations for low buildings [1]	
(2)	Slopes of 30 to 90 percent.	Slopes of 30 to 90 percent.	Slopes of 30 to 90 percent.	Slopes of 30 to 90 percent; susceptible to sliding.	Severe on slopes of 30 to 90 percent.
(2)	(2)	Slopes of 40 to 70 percent; moderately rapid permeability.	Slopes of 40 to 70 percent.	Slopes of 40 to 70 percent; susceptible to sliding.	Severe on slopes of 40 to 70 percent.
(2)	Erodible; slopes as much as 15 percent.	Susceptible to siltation.	Susceptible to siltation of channels; difficult to establish plants.	All features favorable, except where slopes are as much as 15 percent.	Slight on slopes of 0 to 7 percent; moderate on slopes of 7 to 15 percent.
(2)	Slopes as much as 25 percent.	Slopes as much as 25 percent; other features favorable.	(3)	Moderate shrink-swell potential; high shear strength; slopes as much as 25 percent.	Moderate on slopes of 7 to 15 percent; severe on slopes of more than 15 percent.
(2)	(2)	Many stones below a depth of 3 feet; poor workability; low fertility.	Poor workability; low fertility.	High shrinkage; high compressibility; low shear strength.	Moderate on slopes of 5 to 15 percent; severe on slopes of more than 15 percent.
Moderately slow permeability.	Moderately slow permeability.	Poor workability	Difficult to establish plants; poor workability.	Low shear strength; high shrink-swell potential.	Severe: moderately slow permeability.
(2)	Slopes as much as 35 percent.	All features favorable on slopes not more than 20 percent.	Difficult to establish plants.	Slopes as much as 35 percent.	Slight on slopes of 0 to 7 percent; moderate on slopes of 7 to 15 percent; severe on slopes of more than 15 percent.
Ironstone layer at a depth of about 15 inches; wetness.	(2)	(2)	(2)	Poorly drained; slopes as much as 70 percent; low shear strength.	Severe: shallow to ironstone layers; steep and very steep slopes; always wet.
(2)	(2)	Many stones below a depth of 3 feet; poor workability; low fertility.	Poor workability; low fertility.	High shrinkage; high compressibility; low shear strength.	Moderate on slopes of 5 to 15 percent; severe on slopes of more than 15 percent.
(2)	Moderately slow permeability.	Poor workability	Poor workability; difficult to establish plants.	Moderate shrink-swell potential.	Severe: moderately slow permeability.
(2)	Slopes of 7 to 25 percent; high available water capacity; moderately rapid permeability.	Unstable material; cinders at a depth of 20 to 40 inches.	Cinders at a depth of 20 to 40 inches.	Slopes as much as 25 percent; cinders at a depth of 20 to 40 inches.	Severe: slopes generally more than 10 percent; rapid permeability in substratum.

TABLE 3.—*Engineering*

Soil series and map symbols	Suitability as a source of—		Soil features affecting—		
	Topsoil	Road fill	Highway location	Farm ponds	
				Reservoir areas	Embankments
Ioleau: IoB, IoC, IoD2, IoE2.	Fair: low fertility.	Good	Slopes as much as 35 percent.	Slopes as much as 35 percent; slow to moderately slow permeability.	(3)
Jaucas: JaC, JfB, JkB	Poor: low available water capacity.	Poor: unstable; highly erodible.	Unstable slopes; erodible.	Sandy pervious material.	Highly pervious; poor stability.
JcC	Poor: low available water capacity; saline.	Poor: unstable; highly erodible; high water table.	Unstable slopes; erodible; high water table.	Sandy pervious material; high water table.	Highly pervious; poor stability; high water table.
JL. For Blown-out part, see Blown-out land.	Fair: low fertility.	Good	Erodible where embankments are exposed.	Rapid permeability	Erodible; high compacted density.
Kaena: KaB, KaC, KaeB, KaeC, KaeD, KanE, KavB, KavC.	Poor: very sticky and very plastic.	Poor: very plastic; high shrink-swell potential; poor workability; seepage.	High shrink-swell potential; seepage; poor workability; slopes as much as 35 percent.	Slow to moderately slow permeability; high shrink-swell potential; slopes as much as 35 percent.	Poor workability; high shrink-swell potential; poor compaction characteristics.
Kahana: KbB, KbC, KbD.	Good	Good	Slopes as much as 25 percent.	Moderately rapid permeability; slopes as much as 25 percent.	(3)
Kahanui: KASD, KATD	Poor: very low fertility.	Fair to good: wet in winter.	Local seepage; slopes as much as 20 percent.	Moderately rapid permeability; slopes as much as 20 percent; local seepage.	(4)
Kailua: KBID	Fair: dehydrates irreversibly; low fertility.	Poor: low shear strength; high compressibility; poor workability; thixotropic.	Low bearing capacity; high compressibility; poor workability; slopes as much as 25 percent.	Moderately rapid permeability; slopes as much as 25 percent.	Thixotropic; high compressibility; poor workability; low compacted density.
Kaimu: KCXD	Poor: extremely stony; fragmental Aa lava at a depth of less than 8 inches.	Good	Fragmental Aa lava; slopes as much as 25 percent.	Fragmental Aa lava; very rapid permeability.	Fragmental Aa lava; highly pervious.

See footnotes at end of table.

interpretations—Continued

Soil features affecting—Continued					
Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	Foundations for low buildings [1]	Degree and kind of limitations for septic tank filter fields
(2)	Moderate to severe erosion hazard where slopes are more than 20 percent; slow to moderately slow permeability.	Slopes as much as 35 percent.	Slopes as much as 35 percent.	Slopes as much as 35 percent.	Severe: moderately slow to slow permeability.
(2)	Low available water capacity; rapid intake rate.	Unstable embankments; sandy material; rapid permeability.	Highly erodible; low available water capacity; low fertility.	(3)	Slight: rapid permeability.
Rapid permeability; high water table.	Low available water capacity; rapid intake rate; high water table.	Unstable embankments; sandy material; rapid permeability; high water table.	Highly erodible; low available water capacity; low fertility; high water table.	High water table	Severe: high water table.
(2)	Slow intake rate	Susceptible to siltation.	Low fertility; difficult to establish plants.	(3)	Slight: rapid permeability.
Slow permeability; seepage.	Slow intake rate; poorly drained; slow permeability.	Poor workability; poorly drained; high shrink-swell potential.	Poorly drained; poor workability.	High shrink-swell potential; poorly drained; low shear strength; seepage.	Severe: slow permeability; seepage.
(2)	Slopes as much as 25 percent.	All features favorable where slopes are not more than 20 percent.	Slopes as much as 25 percent.	High shear strength; slopes as much as 25 percent.	Slight on slopes of 0 to 7 percent; moderate on slopes of 7 to 15 percent; severe on slopes of more than 15 percent.
(2)	(2)	Slopes as much as 20 percent; saprolite at a depth of 24 to 36 inches.	Very low fertility	Local seepage; slopes as much as 20 percent.	Slight on slopes of not more than 5 percent; severe on slopes of more than 5 percent; downslope seepage.
(2)	(2)	Poor workability	Poor workability	High shrinkage; low shear strength; high compressibility; slopes as much as 25 percent.	Slight on slopes of 0 to 5 percent; moderate on slopes of 5 to 10 percent; severe on slopes of more than 10 percent; moderately rapid permeability.
(2)	Rapid intake rate; very low available water capacity.	(2)	Extremely stony; poor workability.	Extremely stony; high bearing capacity; slopes as much as 25 percent.	Severe: lack of filter material.

TABLE 3.—*Engineering*

Soil series and map symbols	Suitability as a source of—		Soil features affecting—		
	Topsoil	Road fill	Highway location	Farm ponds	
				Reservoir areas	Embankments
Kaipoioi: KDIE	Good	Fair: high organic-matter content; low compacted density.	Slopes as much as 40 percent; moderate compressibility; unstable slopes.	Moderately rapid permeability; slopes as much as 40 percent.	Low compacted density; high organic-matter content.
KDVE	Good, except stony.	Fair: high organic-matter content: low compacted density; rocky.	Slopes as much as 40 percent; moderate compressibility; unstable slopes; rockiness.	Moderately rapid permeability; slopes as much as 40 percent; rockiness.	Low compacted density; high organic-matter content; rockiness.
Kalae: KcB, KcC, KcC3, KcD3, KcE3.	Fair: low fertility.	Good	Slopes as much as 40 percent.	Moderately rapid permeability; slopes as much as 40 percent.	(3)
Kalapa: KdD, KdE, KdF	Fair: low fertility.	Good	Slopes as much as 70 percent.	Moderately rapid permeability; slopes as much as 70 percent.	(4)
KEHF	Fair: low fertility; rocky.	Good, except rocky.	Slopes as much as 70 percent; rockiness.	Slopes as much as 70 percent; moderately rapid permeability; rockiness.	Rockiness. See also (4).
Kalaupapa: KFID	Poor: bedrock at a depth of less than 20 inches.	Poor: bedrock at a depth of less than 20 inches; rocky.	Slopes as much as 25 percent; rockiness; bedrock at a depth of less than 20 inches.	Bedrock at a depth of less than 20 inches; slopes as much as 25 percent; rockiness.	Limited volume of material; piping hazard; rockiness.
Kalihi: Ke	Poor: very sticky and very plastic; wet.	Poor: high shrink-swell potential; poor workability.	High shrink-swell potential; wetness; poor workability.	High water table; high shrink-swell potential; slow permeability.	High shrink-swell potential; low shear strength; poor compaction characteristics.
Kaloko: Kf, Kfa, Kfb	Poor: marl at a depth of less than 20 inches; high clay content.	Poor: high shrink-swell potential; poor workability.	High shrink-swell potential; wetness; poor workability.	Slow to moderately slow permeability; high shrink-swell potential.	Clayey; high shrink-swell potential; poor compaction characteristics; low shear strength.
Kamaole: KGKC, KGLC.	Poor: stony; less than 24 inches to fragmental Aa lava.	Good, except stony.	Fragmental Aa lava at a depth of less than 24 inches; stoniness.	Fragmental Aa lava at a depth of 16 to 24 inches; high seepage rate.	Limited volume of material; rapid seepage rate; stoniness.

See footnotes at end of table.

interpretations—Continued

Soil features affecting—Continued					Degree and kind of limitations for septic tank filter fields
Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	Foundations for low buildings [1]	

Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	Foundations for low buildings [1]	Degree and kind of limitations for septic tank filter fields
[2]	Rapid intake rate; slopes of 7 to 40 percent.	Slopes of 7 to 40 percent; erodible.	Erodible; slopes as much as 40 percent.	Slopes as much as 40 percent; moderate compressibility; low shear strength.	Severe: slopes generally more than 10 percent.
[2]	Rapid intake rate; slopes of 7 to 40 percent; rockiness.	Slopes of 7 to 40 percent; erodible; rockiness.	Erodible; slopes as much as 40 percent; rockiness.	Slopes as much as 40 percent; moderate compressibility; low shear strength; rockiness.	Severe: slopes generally more than 10 percent; rockiness.
[2]	Slopes as much as 40 percent; moderately rapid permeability.	All features favorable on slopes of not more than 20 percent.	Slopes as much as 40 percent.	High shear strength; slopes as much as 40 percent.	Slight on slopes of 0 to 7 percent; moderate on slopes of 7 to 15 percent; severe on slopes of more than 15 percent.
[2]	Slopes as much as 70 percent.	All features favorable on slopes of not more than 20 percent.	Slopes as much as 70 percent.	Moderate shrink-swell potential; high shear strength; slopes as much as 70 percent.	Moderate on slopes of 8 to 15 percent; severe on slopes of more than 15 percent.
[2]	Slopes as much as 70 percent; rockiness.	Slopes of 40 to 70 percent; rockiness.	Slopes of 40 to 70 percent; rockiness.	Slopes of 40 to 70 percent; rockiness.	Severe: slopes of 40 to 70 percent; rockiness.
[2]	Bedrock at a depth of less than 20 inches; rockiness.	Bedrock at a depth of less than 20 inches; rockiness.	Bedrock at a depth of less than 20 inches; rockiness; slopes as much as 25 percent.	Bedrock at a depth of less than 20 inches; slopes as much as 25 percent; rockiness.	Severe: bedrock at a depth of less than 20 inches.
Slow permeability; high water table.	Slow intake rate; slow permeability.	Poor workability; wetness.	Wetness; poor workability.	High shrink-swell potential; poor drainage.	Severe: slow permeability; poor drainage.
Slow to moderately slow permeability; high water table.	Slow to moderately slow permeability.	Poor workability; wetness; marl layer at shallow depth.	Poor workability; wetness; shallow to marl.	High shrink-swell potential; wetness; low shear strength.	Severe: slow to moderately slow permeability; poorly drained.
[2]	Low available water capacity; fragmental Aa lava at a depth of 16 to 24 inches; stoniness.	Fragmental Aa lava at a depth of less than 24 inches; stoniness.	Highly erodible; fragmental Aa lava at a depth of less than 24 inches; stoniness; difficult to establish plants.	Stoniness; fragmental Aa lava at a depth of less than 24 inches.	Severe: lack of filter material.

TABLE 3.—*Engineering*

Soil series and map symbols	Suitability as a source of—		Soil features affecting—		
	Topsoil	Road fill	Highway location	Farm ponds	
				Reservoir areas	Embankments
Kaneohe: KgB, KgC, KHMC, KHME, KHMF, KHOF.	Fair: low fertility.	Good	Slopes as much as 65 percent.	Moderately rapid permeability; slopes as much as 65 percent.	([4])
Kanepuu: KhB, KhB2, KhC, KhC2.	Good	Good	([3])	Moderate permeability.	([3])
Kapaa: KkB, KkC, KkD, KkE, KlG.	Poor: very low fertility.	Good	Slopes as much as 100 percent.	Slopes as much as 100 percent; moderately rapid permeability.	([4])
Kapuhikani: KKTC	Poor: very sticky and very plastic; bedrock at a depth of 20 to 36 inches; stony.	Poor: very plastic; high shrink-swell potential; poor workability; stony.	High shrink-swell potential; poor workability; stoniness.	High shrink-swell potential; slow permeability; bedrock at a depth of 20 to 36 inches.	Clayey; high shrink-swell potential; poor compaction characteristics; stoniness.
Kaupo: KLUD, KLVD	Poor: stony; fragmental Aa lava at a depth of 20 to 40 inches.	Good, except stony.	Stoniness; slopes as much as 25 percent.	Stoniness; slopes as much as 25 percent; fragmental Aa lava at a depth of 20 to 40 inches; high seepage rate.	Stoniness; limited volume of soil material.
Kawaihapai: KlA, KlB, KlC, KlcB.	Good	Good	All features favorable, except occasional local flooding.	Moderate permeability.	([3])
KlbC, KlaA, KlaB	Good, except stony.	Good, except stony.	All features favorable, except occasional local flooding; stoniness.	Moderate permeability; stoniness.	Stoniness
Keaau: KmA, KmaB, KmbA.	Poor: very sticky and very plastic.	Poor: very plastic; high shrink-swell potential; poor workability.	High shrink-swell potential; high water table.	High water table; high shrink-swell potential; slow permeability.	Clayey; high shrink-swell potential; poor compaction characteristics.
Keahua: KnB, KnC, KnaB, KnaC, KnaD, KncC, KnhC.	Good, except cobbly in places.	Good, except cobbly in places.	Slopes as much as 25 percent.	Moderate permeability; slopes as much 25 percent.	([3])
KnbD, KnsC	Good, except stony.	Good, except stony.	Slopes as much as 25 percent; stoniness.	Moderate permeability; slopes as much as 25 percent; stoniness.	Stoniness

See footnotes at end of table.

interpretations—Continued

Soil features affecting—Continued					Degree and kind of limitations for septic tank filter fields
Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	Foundations for low buildings [1]	
(2)	(2)	All features favorable on slopes not more than 20 percent.	Slopes as much as 65 percent.	Slopes as much as 65 percent.	Slight on slopes of 3 to 8 percent; moderate on slopes of 8 to 15 percent; severe on slopes of more than 15 percent.
(2)	Slopes as much as 15 percent.	(3)	Difficult to establish plants.	Slopes as much as 15 percent.	Slight on slopes of 3 to 7 percent; moderate on slopes of 7 to 15 percent.
(2)	(2)	Slopes as much as 100 percent.	Very low fertility; slopes as much as 100 percent.	Slopes as much as 100 percent.	Slight on slopes of 3 to 8 percent; moderate on slopes of 8 to 15 percent; severe on slopes of more than 15 percent.
(2)	Slow intake rate; stoniness.	Poor workability; stoniness; bedrock at a depth of 20 to 36 inches.	Poor workability; stoniness; bedrock at a depth of 20 to 36 inches; difficult to establish plants.	High shrink-swell potential; stoniness; bedrock at a depth of 20 to 36 inches.	Severe: slow permeability.
(2)	Fragmental Aa lava at a depth of 20 to 40 inches; stoniness.	Stoniness; fragmental Aa lava at a depth of 20 to 40 inches.	Stoniness; fragmental Aa lava at a depth of 20 to 40 inches.	Stoniness; slopes as much as 25 percent; fragmental Aa lava at a depth of 20 to 40 inches.	Severe: lack of filter material.
(2)	Slopes as much as 15 percent.	(3)	(3)	Slopes as much as 15 percent; high shear strength.	Slight on slopes of 0 to 7 percent; moderate on slopes of 7 to 15 percent.
(2)	Slopes as much as 15 percent; stoniness.	Stoniness	Stoniness	Slopes as much as 15 percent; high shear strength; stoniness.	Slight on slopes of 0 to 7 percent; moderate on slopes of 7 to 15 percent; stoniness.
Slow permeability; high water table.	Slow intake rate; slow permeability.	Poor workability; consolidated coral sand at a depth of 20 to 30 inches.	Poorly drained; poor workability; consolidated coral sand at a depth of 20 to 30 inches.	High shrink-swell potential; high water table; low shear strength.	Severe: slow permeability; high water table.
(2)	Slopes as much as 25 percent.	Susceptible to siltation.	Susceptible to siltation of channels; difficult to establish plants.	Slopes as much as 25 percent.	Slight on slopes of 3 to 7 percent; moderate on slopes of 7 to 15 percent; severe on slopes of more than 15 percent.
(2)	Slopes as much as 25 percent; stoniness.	Susceptible to siltation; stoniness.	Susceptible to siltation of channels; difficult to establish plants; stoniness.	Slopes as much as 25 percent; stoniness.	Moderate on slopes of 7 to 15 percent; severe on slopes of more than 15 percent.

TABLE 3.—*Engineering*

Soil series and map symbols	Suitability as a source of—		Soil features affecting—		
	Topsoil	Road fill	Highway location	Farm ponds	
				Reservoir areas	Embankments
Kealia: KMW	Poor: toxic salts; high water table.	Poor: high water table.	High water table; flooding hazard.	High water table; moderately rapid permeability.	Erodible: difficult to vegetate; piping hazard.
Keawakapu: KNXD	Poor: stony; 12 to 30 inches of soil material.	Fair: stony; limited volume of material.	Stoniness; slopes as much as 25 percent.	Fragmental Aa lava at a depth of 12 to 30 inches: moderate permeability.	Limited volume of material; stoniness.
Kekaha: KoA, KoB, KobA	Good	Good	(3)	Moderate permeability.	(3)
KOYE	Good, except stony.	Good, except stony.	Extremely stony; slopes as much as 35 percent.	Stoniness; slopes as much as 35 percent.	Stoniness
Kemoo: KpB, KpC, KpD, KpE, KpF, KPZ. For Badland part of KPZ, see Badland.	Good	Good	Slopes as much as 70 percent.	Moderate to moderately rapid permeability; slopes as much as 70 percent.	(3)
Koele: KrB, KrC, KrD	Good	Good	Slopes as much as 25 percent.	Moderately rapid permeability; slopes as much as 25 percent.	Pervious material below a depth of 3 feet.
KRX, KRL. For Badland part of KRL, see Badland.	Good, except rocky.	Good, except rocky.	Slopes as much as 60 percent; rockiness.	Slopes as much as 60 percent; rockiness.	Rockiness
Kokee: KSKE, KSKF	Fair: low fertility.	Good	Slopes as much as 70 percent.	Slopes as much as 70 percent; moderately rapid permeability.	(4)
Koko: KsB, KsC, KsD	Good	Fair: unstable slopes; erodible.	Erodible; slopes as much as 25 percent; unstable slopes.	Slopes as much as 25 percent; moderate permeability; tuff or cinders at a depth of 20 to 50 inches.	Low compacted density; tuff or cinders at a depth of 20 to 50 inches; subject to piping.

See footnotes at end of table.

interpretations—Continued

Soil features affecting—Continued					Degree and kind of limitations for septic tank filter fields
Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	Foundations for low buildings [1]	
Low, wet areas; high water table; flooding hazard; saline.	High water table; saline.	Subject to overflow from high tides; high water table.	High water table; saline; difficult to establish plants.	High water table; flooding hazard; subject to tidal action.	Severe: high water table; subject to tidal action.
[2]	Shallow soil; stoniness; slopes as much as 25 per-percent.	Fragmental Aa lava at a depth of 12 to 30 inches; stoniness.	Fragmental Aa lava at a depth of 12 to 30 inches; stoniness; difficult to establish plants.	Fragmental Aa lava at a depth of 12 to 30 inches; stoniness; slopes as much as 25 percent.	Severe: lack of filter material.
[2]	[3]	[3]	Difficult to establish plants unless irrigated.	[3]	Slight: moderate permeability.
[2]	Stoniness: slopes as much as 35 percent.	Stoniness: slopes as much as 35 percent.	Stoniness: slopes as much as 35 percent; difficult to establish plants unless irrigated.	Slopes as much as 35 percent; stoniness.	Moderate on slopes of 0 to 10 percent; severe on slopes of more than 10 percent.
[2]	Slopes as much as 70 percent.	All features favorable on slopes of not more than 20 percent.	Slopes as much as 70 percent.	Slopes as much as 70 percent; high bearing strength.	Slight on slopes of 2 to 6 percent; moderate on slopes of 6 to 12 percent; severe on slopes of more than 12 percent.
[2]	Slopes as much as 25 percent; moderately rapid permeability.	[3]	Difficult to establish plants unless irrigated.	Slopes as much as 25 percent.	Slight on slopes of 3 to 7 percent; moderate on slopes of 7 to 15 percent; severe on slopes of more than 15 percent.
[2]	Rockiness; uneven topography; slopes as much as 60 percent.	Rockiness; uneven topography; slopes as much as 60 percent.	Rockiness; slopes as much as 60 percent.	Slopes as much as 60 percent; rockiness.	Slight on slopes of 3 to 7 percent; moderate on slopes of 7 to 15 percent; severe on slopes of more than 15 percent in other than rocky areas.
[2]	[2]	Slopes as much as 70 percent.	Slopes as much as 70 percent.	Slopes as much as 70 percent; low fertility.	Severe: slopes generally more than 10 percent.
[2]	Erodible; slopes as much as 25 percent; moderate permeability.	Erodible; tuff or cinders at a depth of 20 to 50 inches; slopes as much as 25 percent.	Erodible; difficult to establish plants unless irrigated.	Tuff or cinders at a depth of 20 to 50 inches; slopes as much as 25 percent.	Slight on slopes of 2 to 6 percent; moderate on slopes of 6 to 12 percent; severe on slopes of more than 12 percent.

TABLE 3.—*Engineering*

Soil series and map symbols	Suitability as a source of—		Soil features affecting—		
	Topsoil	Road fill	Highway location	Farm ponds	
				Reservoir areas	Embankments
Kokokahi:					
KtC	Poor: very sticky and very plastic.	Poor: very plastic; wet; poor workability; high shrink-swell potential.	High shrink-swell potential; poor workability; seepage.	High shrink-swell potential; seepage; slow to moderately slow permeability.	Poor workability; high shrink-swell potential; poor compaction characteristics.
KTKE	Poor: very sticky and very plastic.	Poor: very plastic; wet; poor workability; high shrink-swell potential; stoniness.	High shrink-swell potential; poor workability; seepage; slopes as much as 35 percent; stoniness.	High shrink-swell potential; seepage; slow to moderately slow permeability; stoniness.	Poor workability; high shrink-swell potential; poor compaction characteristics; stoniness.
Kolekole: KuB, KuC, KuD.	Good	Good	Slopes as much as 25 percent.	Slopes as much as 25 percent; moderate permeability.	Erodible
Koloa: KvB, KvC, KvD	Fair: soil material 20 to 40 inches deep over bedrock; stony.	Fair: 20 to 40 inches deep; stony.	Bedrock at a depth of 20 to 40 inches; slopes as much as 25 percent.	Bedrock at a depth of 20 to 40 inches; slopes as much as 25 percent; moderately rapid permeability.	Bedrock at a depth of 20 to 40 inches; high compacted density.
Kolokolo:					
Kw	Fair: low fertility.	Good	Subject to stream overflow.	Moderate permeability; subject to stream overflow.	(4)
KUL	Fair: stony; low fertility.	Poor: stony	Stoniness; subject to stream overflow.	Moderate permeability; subject to stream overflow; stoniness.	Stoniness. See also (4).
Koolau: KVSB, KVSE	Poor: always wet; low fertility.	Poor: low shear strength; always wet.	Wetness; low shear strength; poor workability.	Wetness; rapid permeability to a depth of 30 inches.	Wetness; poor workability; poor compaction characteristics.
Kula:					
KxC, KxD, KxaD	Good	Fair: unstable slopes; erodible.	Unstable slopes; erodible; slopes as much as 20 percent.	Moderately rapid permeability; slopes as much as 20 percent.	Poor stability; poor compaction characteristics; piping hazard.
KxbE	Good, except rocky.	Fair: unstable slopes; erodible; rocky.	Unstable slopes; erodible; rockiness; slopes as much as 40 percent.	Moderately rapid permeability; rockiness; slopes as much as 40 percent.	Poor stability; poor compaction characteristics; piping hazard; rockiness.
Kunia: KyA, KyB, KyC	Good	Good	(3)	Moderate permeability; slopes as much as 15 percent.	(3)

See footnotes at end of table.

interpretations—Continued

Soil features affecting—Continued					Degree and kind of limitations for septic tank filter fields
Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	Foundations for low buildings [1]	
Slow to moderately slow permeability; seepage.	Slow intake rate; slow to moderately slow permeability.	High shrink-swell potential; poor workability.	Poor workability	High shrink-swell potential; low shear strength; seepage; susceptible to sliding.	Severe: slow and moderately slow permeability; seepage.
Slow to moderately slow permeability; seepage; stoniness.	Slow intake rate; slow to moderately slow permeability; slopes as much as 35 percent; stoniness.	High shrink-swell potential; poor workability; slopes as much as 35 percent; stoniness.	Poor workability; slopes as much as 35 percent; stoniness.	High shrink-swell potential; low shear strength; seepage; susceptible to sliding; slopes as much as 35 percent; stoniness.	Severe: slow to moderately slow permeability; seepage.
(2)	Thin panlike layer at a depth of 15 to 50 inches; slopes as much as 25 percent.	Slopes as much as 25 percent; thin panlike layer at a depth of 15 to 50 inches.	Thin panlike layer at a depth of 15 to 50 inches; slopes as much as 25 percent.	Slopes as much as 25 percent.	Slight on slopes of 1 to 6 percent; moderate on slopes of 6 to 12 percent; severe on slopes of more than 12 percent.
(2)	Stoniness; slopes as much as 25 percent; bedrock at a depth of 20 to 40 inches.	Stoniness; slopes as much as 25 percent; bedrock at a depth of 20 to 40 inches.	Stoniness; bedrock at a depth of 20 to 40 inches; slopes as much as 25 percent.	Bedrock at a depth of 20 to 40 inches; slopes as much as 25 percent.	Severe: bedrock at a depth of 20 to 40 inches.
(2)	(2)	Subject to stream overflow.	Subject to stream overflow and siltation.	Subject to stream overflow.	Severe: subject to stream overflow.
(2)	(2)	Subject to stream overflow; stoniness.	Subject to stream overflow; stoniness.	Subject to stream overflow; stoniness.	Severe: subject to stream overflow; stoniness.
High water table; moderately slow permeability in substratum.	(2)	Wetness; poor workability.	Poor workability; wetness.	Wetness; low shear strength; high compressibility.	Severe: poorly drained.
(2)	Moderately rapid permeability; erodible; slopes as much as 20 percent.	Susceptible to soil blowing and siltation; highly erodible.	Highly erodible; susceptible to siltation.	Moderate compressibility; piping hazard; slopes as much as 20 percent.	Moderate on slopes of 4 to 12 percent; severe on slopes o more than 12 percent.
(2)	Rockiness; slopes as much as 40 percent.	Susceptible to wind erosion and siltation; highly erodible; rockiness; slopes as much as 40 percent.	Highly erodible; susceptible to siltation of channels; rockiness; slopes as much as 40 percent.	Rockiness; slopes as much as 40 percent.	In other than rocky areas, moderate on slopes of 4 to 12 percent; severe on slopes of more than 12 percent.
(2)	Moderate permability; slopes as much as 15 percent.	(3)	Slopes as much as 15 percent.	Slopes as much as 15 percent.	Slight on slopes of 0 to 8 percent; moderate on slopes of 8 to 15 percent.

TABLE 3.—*Engineering*

Soil series and map symbols	Suitability as a source of—		Soil features affecting—		
	Topsoil	Road fill	Highway location	Farm ponds	
				Reservoir areas	Embankments
Kunuweia: KZC	Poor: very low fertility.	Fair to good: wet in winter.	Slopes as much as 15 percent.	Moderately rapid permeability.	(4)
Lahaina: LaA, LaB, LaB3, LaC, LaC3, LaD, LaD3, LaE3.	Good	Good	Slopes as much as 40 percent.	Slopes as much as 40 percent; moderate permeability.	(3)
Laumaia: LME, LMF	Good	Fair: moderate compressibility; unstable slopes; low compacted density.	Moderate compressibility; moderate bearing capacity; unstable; slopes as much as 70 percent.	High seepage rate; slopes as much as 70 percent.	Low compacted density; high erodibility; subject to piping; unstable.
LNE	Good, except stony.	Fair: moderate compressibility; unstable slopes; low compacted density; stony.	Moderate compressibility; moderate bearing capacity; unstable slopes; slopes as much as 40 percent; stoniness.	Stoniness; slopes as much as 40 percent; high seepage rate.	Low compacted density; high erodibility; subject to piping; unstable; stoniness.
Lawai: LcB, LcC, LcD	Fair: low fertility.	Fair: subject to seepage.	Subject to seepage; slopes as much as 25 percent.	Moderate to moderately rapid permeability; slopes as much as 25 percent.	Poor workability. See also (4).
Leilehua: LeB, LeC	Fair: low fertility.	Good	(3)	Moderately rapid permeability.	(4)
Lihue: LhB, LhC, LhD, LhE2, LlB, LlC.	Good	Good	All features favorable, except slopes as much as 40 percent.	Moderately rapid permeability; slopes as much as 40 percent.	High shear strength; high compacted density.
Lolekaa: LoB, LoC, LoD, LoE, LoF.	Fair: low fertility.	Good	All features favorable, except slopes as much as 70 percent.	Moderately rapid permeability; slopes as much as 70 percent.	(4)

See footnotes at end of table.

interpretations—Continued

Soil features affecting—Continued: Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	Foundations for low buildings [1]	Degree and kind of limitations for septic tank filter fields
(2)	(2)	(3)	Very low fertility	Moderate bearing capacity; slopes as much as 15 percent.	Moderate: slopes generally more than 5 percent.
(2)	Moderate permeability; slopes as much as 40 percent.	Slopes as much as 40 percent.	Slopes as much as 40 percent.	Slopes as much as 40 percent.	Slight on slopes of 0 to 7 percent; moderate on slopes of 7 to 15 percent; severe on slopes of more than 15 percent.
(2)	Slopes as much as 70 percent.	Slopes as much as 70 percent; highly erodible.	Highly erodible; slopes as much as 70 percent.	Moderate bearing capacity; moderate compressibility; slopes as much as 70 percent.	Severe: slopes generally more than 10 percent.
(2)	Stoniness; slopes as much as 40 percent.	Highly erodible; stoniness; slopes as much as 40 percent.	Highly erodible; slopes as much as 40 percent; stoniness.	Moderate bearing capacity; moderate compressibility; stoniness; slopes as much as 40 percent.	Severe: slopes generally more than 10 percent.
Subject to seepage.	Slopes as much as 25 percent; subject to seepage.	Poor workability; subject to seepage; slopes as much as 25 percent.	Poor workability; slopes as much as 25 percent.	Subject to seepage; slopes as much as 25 percent.	Severe: subject to seepage; slopes as much as 25 percent.
(2)	Moderately rapid permeability; slopes as much as 12 percent.	(3)	Slopes as much as 12 percent.	Moderate shrink-swell potential; high shear strength; slopes as much as 12 percent.	Slight on slopes of 0 to 6 percent; moderate on slopes of 6 to 12 percent.
(2)	Moderately rapid permeability; slopes as much as 40 percent.	All features favorable where slopes are not more than 20 percent.	Slopes as much as 40 percent.	Slopes as much as 40 percent; high shear strength.	Slight on slopes of 0 to 8 percent; moderate on slopes of 8 to 15 percent; severe on slopes of more than 15 percent.
(2)	(2)	Slopes as much as 70 percent.	Slopes as much as 70 percent.	Susceptible to sliding; slopes as much as 70 percent.	Slight on slopes of 3 to 8 percent; moderate on slopes of 8 to 15 percent; severe on slopes of more than 15 percent.

TABLE 3.—*Engineering*

Soil series and map symbols	Suitability as a source of—		Soil features affecting—		
	Topsoil	Road fill	Highway location	Farm ponds	
				Reservoir areas	Embankments
Lualualei: LuA, LuB	Poor: very sticky and very plastic.	Poor: very plastic; high shrink-swell potential.	Very plastic; high shrink-swell potential.	High shrink-swell potential; slow permeability.	Low shear strength; very plastic; high shrink-swell potential.
LvA, LvB, LPE	Poor: very sticky and very plastic; stony.	Poor: very plastic; high shrink-swell potential; stony.	Very plastic; high shrink-swell potential; stoniness; slopes as much as 35 percent.	High shrink-swell potential; slow permeability.	Low shear strength; very plastic; high shrink-swell potential; stoniness.
Mahana: MaC, MaD, MaD3, MaE, MaE3, McC2, McD2, McE2, MBL. For Badland part of MBL, see Badland.	Fair: low fertility.	Fair: erodible; unstable on steep slopes.	Slopes as much as 35 percent.	Moderately rapid permeability; slopes as much as 35 percent.	Poor stability; erodible; subject to piping.
Makaalae: MID, MWE	Poor: very sticky and very plastic.	Poor: very plastic; high shrink-swell potential.	High shrink-swell potential; slopes as much as 40 percent.	High shrink-swell potential; slopes as much as 40 percent; moderate permeability.	High shrink-swell potential; poor workability; limited volume of material.
MJD	Poor: very sticky and very plastic; stony.	Poor: very plastic; high shrink-swell potential; stony.	High shrink-swell potential; slopes as much as 25 percent; stoniness.	High shrink-swell potential; slopes as much as 25 percent; moderate permeability.	High shrink-swell potential; poor workability; limited volume of material; stoniness.
Makalapa: MdB, MdC, MdD.	Poor: very sticky and very plastic.	Poor: very plastic; high shrink-swell potential.	High shrink-swell potential; poor workability; slopes as much as 20 percent.	High shrink-swell potential; slopes as much as 20 percent; slow permeability.	High shrink-swell potential; low shear strength.
Makapili: MeB, MeC, MeD, MeE.	Fair: low fertility.	Good	All features favorable, except slopes as much as 40 percent.	Moderately rapid permeability; slopes as much as 40 percent.	(4)
Makawao: MfB, MfC	Fair: low fertility.	Fair to good: fair compaction characteristics.	(3)	Moderately rapid permeability.	Moderate compressibility; moderate shear strength.
Makaweli: MgB, MgC, MgD, MgE2, MhB, MhC, MhD, MhE.	Good, except stony in places.	Good, except stony in places.	Slopes as much as 35 percent.	Moderate permeability; slopes as much as 35 percent.	All features favorable, except stony in places.

See footnotes at end of table.

interpretations—Continued

Soil features affecting—Continued					Degree and kind of limitations for septic tank filter fields
Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	Foundations for low buildings [1]	
(2)	Slow intake rate; high available water capacity.	Poor workability; high shrink-swell potential.	Poor workability; difficult to establish plants.	High shrink-swell potential; low shear strength.	Severe: slow permeability.
(2)	Slow intake rate; high available water capacity; slopes as much as 35 percent.	Poor workability; high shrink-swell potential; stoniness; slopes as much as 35 percent.	Poor workability; difficult to establish plants; stoniness; slopes as much as 35 percent.	High shrink-swell potential; low shear strength; stoniness; susceptible to sliding on slopes more than 15 percent.	Severe: slow permeability; slopes as much as 35 percent.
(2)	Slopes as much as 35 percent; erodible.	Slopes as much as 35 percent; erodible; susceptible to siltation.	Slopes as much as 35 percent; susceptible to siltation of channels.	Slopes as much as 35 percent.	Moderate on slopes of 6 to 12 percent; severe on slopes of more than 12 percent.
(2)	Slopes as much as 40 percent; moderate permeability.	Poor workability; slopes as much as 40 percent.	Poor workability; slopes as much as 40 percent.	High shrink-swell potential; slopes as much as 40 percent; low shear strength.	Severe: slopes generally more than 10 percent.
(2)	Slopes as much as 25 percent; stoniness.	Poor workability; slopes as much as 25 percent; stoniness.	Poor workability; stoniness; slopes as much as 25 percent.	High shrink-swell potential; slopes as much as 25 percent; stoniness.	Severe: slopes generally more than 10 percent.
(2)	Slow intake rate; slopes as much as 20 percent; high available water capacity.	Poor workability; high shrink-swell potential.	Poor workability; difficult to establish plants.	High shrink-swell potential; low shear strength; susceptible to sliding where slopes are more than 15 percent.	Severe: slow permeability.
(2)	(2)	Slopes as much as 40 percent.	Slopes as much as 40 percent; low fertility.	Slopes as much as 40 percent.	Slight on slopes of 0 to 8 percent; moderate on slopes of 8 to 15 percent; severe on slopes of more than 15 percent.
(2)	High intake rate; moderately rapid permeability.	(3)	Slopes as much as 15 percent; low fertility.	Moderate shrink-swell potential; moderate shear strength.	Slight on slopes of 3 to 7 percent; moderate on slopes of 7 to 15 percent.
(2)	Slopes as much as 35 percent; stony in places.	Susceptible to siltation; slopes as much as 35 percent; stony in places.	Susceptible to siltation of channels; difficult to establish plants; stony in places.	Slopes as much as 35 percent.	Slight on slopes of 0 to 6 percent; moderate on slopes of 6 to 12 percent; severe on slopes of more than 12 percent.

TABLE 3.—*Engineering*

Soil series and map symbols	Suitability as a source of—		Soil features affecting—		
	Topsoil	Road fill	Highway location	Farm ponds	
				Reservoir areas	Embankments
Makena: MXC	Good, except stony in places.	Fair: erodible; unstable slopes; stony in places.	Erodible; unstable slopes; stoniness.	Moderately rapid permeability.	Poor stability; poor compaction characteristics; erodible; piping hazard; stoniness in places.
Makiki: MkA, MlA	Fair: very sticky and very plastic; stony in places.	Fair: very sticky and very plastic; moderate shrink-swell potential; stony in places.	Very sticky and very plastic; moderate shrink-swell potential; stony in places.	Moderate shrink-swell potential; moderately rapid permeability; stony in places.	Moderate shrink-swell potential; fair compaction characteristics; stony in places.
Mala: MmA, MmB	Good	Good	Subject to flooding on 0 to 3 percent slopes.	Subject to flooding on 0 to 3 percent slopes; moderate permeability.	(3)
Malama: MYD	Poor: extremely stony; less than 10 inches to fragmental Aa lava.	Good: fragmental Aa lava at a depth of less than 10 inches.	Fragmental Aa lava.	Very rapidly permeable; fragmental Aa lava.	Fragmental Aa lava at a depth of less than 10 inches.
Mamala: MnC	Poor: coral below a depth of 8 to 20 inches.	Poor: less than 20 inches deep over coral; stony.	Coral at a depth of less than 20 inches; stoniness.	Coral at a depth of less than 20 inches; moderate permeability.	Limited volume of material; stoniness; coral at a depth of less than 20 inches.
Manana: MoB, MoC, MoD2, MpB, MpC, MpD, MpD2, MpE.	Good	Good	Slopes as much as 40 percent.	Slopes as much as 40 percent; moderate permeability.	Slopes as much as 40 percent.
Mokuleia:					
Mr, Ms, Mt, Mtb	Good to a depth of 20 inches; fair below 20 inches.	Good to a depth of 20 inches; fair below 20 inches; unstable; erodible.	Loose sand at a depth of 20 inches.	Rapid permeability below a depth of 20 inches.	Unstable; erodible material below a depth of 20 inches; subject to piping; poor compaction characteristics.
Mta	Fair: high water table.	Poor: high water table.	High water table	High water table	High water table; unstable; erodible material below a depth of 20 inches; poor compaction characteristics.

See footnotes at end of table.

interpretations—Continued

Soil features affecting—Continued					Degree and kind of limitations for septic tank filter fields
Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	Foundations for low buildings [1]	
(2)	Complex slopes; stoniness; susceptible to wind erosion; erodible.	Stoniness in places; complex slopes; susceptible to wind erosion; erodible.	Highly erodible; stoniness in places; susceptible to siltation of channels; difficult to establish plants; slopes as much as 15 percent.	Stoniness in places; slopes as much as 15 percent.	Moderate on slopes of 3 to 15 percent; stoniness in places.
(2)	(2)	(2)	(2)	Moderate shrink-swell potential; moderate shear strength; stony in places.	Slight: moderately rapid permeability.
(2)	Slopes as much as 7 percent; moderate permeability.	Susceptible to siltation.	Susceptible to siltation of channels; difficult to establish plants.	Subject to flooding on 0 to 3 percent slopes; high shear strength.	Slight, except where subject to flooding.
(2)	Very high intake rate; very low available water capacity; extremely stony.	Fragmental Aa lava at a depth of less than 10 inches.	Fragmental Aa lava at a depth of less than 10 inches.	Extremely stony; fragmental Aa lava at a depth of less than 10 inches.	Severe: lack of filter material; may pollute underground water.
(2)	Coral at a depth of less than 20 inches; stoniness; slopes as much as 12 percent.	Coral at a depth of less than 20 inches; stoniness.	Coral at a depth of less than 20 inches; stoniness; slopes as much as 12 percent; difficult to establish plants.	Coral at a depth of less than 20 inches; slopes as much as 12 percent; stoniness.	Severe: coral at a depth of less than 20 inches.
(2)	Slopes as much as 40 percent; thin panlike layer at a depth of 15 to 50 inches.	All features favorable where slopes are not more than 20 percent.	Slopes as much as 40 percent.	Slopes as much as 40 percent; high shear strength.	Slight on slopes of 2 to 8 percent; moderate on slopes of 8 to 15 percent; severe on slopes of more than 15 percent.
(2)	Rapid permeability and low available water capacity below a depth of 20 inches.	Sand at a depth of less than 20 inches; erodible below a depth of 20 inches.	Sand at a depth of less than 20 inches; erodible below a depth of 20 inches.	Sand at a depth of less than 20 inches; low shrink-swell potential below a depth of 20 inches.	Slight: rapid permeability below a depth of 20 inches.
Low, wet areas; high water table.	High water table; needs drainage.	High water table; sand at a depth of less than 20 inches.	Sand at a depth of less than 20 inches; high water table.	High water table; sand at a depth of less than 20 inches.	Severe: poorly drained.

TABLE 3.—*Engineering*

Soil series and map symbols	Suitability as a source of— Topsoil	Suitability as a source of— Road fill	Soil features affecting— Highway location	Soil features affecting— Farm ponds: Reservoir areas	Soil features affecting— Farm ponds: Embankments
Molokai: MuA, MuB, MuB3, MuC, MuC3, MuD.	Good	Good	Slopes as much as 25 percent.	Slopes as much as 25 percent: moderate permeability.	(3)
MvD3	Poor: soft, weathered rock at a depth of 12 to 20 inches.	Good	Slopes of 15 to 25 percent.	Slopes of 15 to 25 percent; moderate permeability.	(3)
Naiwa: NAC, NAC3	Fair: low fertility.	Fair: erodible; unstable on steep slopes.	Slopes as much as 20 percent; unstable on moderately steep slopes; erodible.	Moderately rapid permeability; slopes as much as 20 percent.	Poor stability; erodible; subject to piping.
Niu: NcC, NcD, NcD2, NcE2.	Good	Good	Slopes as much as 35 percent.	Slopes as much as 35 percent; moderate permeability.	(3)
Niulii: NLE, NME	Fair: low fertility.	Poor: poor workability; low shear strength; low compacted density.	Slopes as much as 30 percent; low bearing capacity; high compressibility.	High seepage rate	Low compacted density; high compressibility; high shrinkage.
Nohili: Nh	Poor: very sticky and very plastic; 20 to 40 inches to high-lime layer.	Poor: high shrink-swell potential; poorly drained; poor workability; highly plastic.	High shrink-swell potential; poorly drained; low shear strength.	High shrink-swell potential; poorly drained; moderately slow permeability.	High shrink-swell potential; very plastic; poor workability; low shear strength.
Nonopahu: NnC	Poor: very sticky and very plastic.	Poor: highly plastic; high shrink-swell potential; poor workability.	High shrink-swell potential; low shear strength.	High shrink-swell potential; moderately slow permeability.	High shrink-swell potential; very plastic; poor workability; low shear strength.
NoC	Poor: very sticky and very plastic; stony.	Poor: highly plastic; high shrink-swell potential; poor workability; stony.	High shrink-swell potential; low shear strength; stoniness.	High shrink-swell potential; moderately slow permeability.	High shrink-swell potential; very plastic; poor workability; low shear strength; stoniness.
Oanapuka: OAD, OED	Poor: stony	Fair: erodible; unstable on steep slopes; slopes as much as 25 percent; stony.	Slopes as much as 25 percent; stoniness.	Slopes as much as 25 percent; moderately rapid permeability.	Poor compaction characteristics; piping hazard; stoniness.

See footnotes at end of table.

interpretations—Continued

Soil features affecting—Continued					Degree and kind of limitations for septic tank filter fields
Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	Foundations for low buildings [1]	
(2)	Slopes as much as 25 percent; moderate permeability.	Slopes as much as 25 percent; susceptible to siltation.	Susceptible to siltation of channels; slopes as much as 25 percent; difficult to establish plants.	Slopes as much as 25 percent.	Slight on slopes of 0 to 7 percent; moderate on slopes of 7 to 15 percent; severe on slopes of more than 15 percent.
(2)	Slopes of 15 to 25 percent; moderate permeability.	Slopes of 15 to 25 percent; susceptible to siltation.	Slopes of 15 to 25 percent; susceptible to siltation of channels; difficult to establish plants.	Slopes of 15 to 25 percent.	Severe: 15 to 25 percent slopes.
(2)	Slopes as much as 20 percent; erodible.	Slopes as much as 20 percent; erodible; subject to siltation.	Slopes as much as 20 percent; susceptible to siltation of channels.	Slopes as much as 20 percent.	Moderate: slopes generally 7 to 15 percent.
(2)	Moderate permeability; slopes as much as 35 percent.	Slopes as much as 35 percent.	Slopes as much as 35 percent.	Slopes as much as 35 percent.	Moderate on slopes of 6 to 12 percent; severe on slopes of more than 12 percent.
(2)	Slopes as much as 30 percent; moderately rapid permeability.	Slopes as much as 30 percent; poor workability.	Slopes as much as 30 percent; poor workability.	Low bearing capacity; high compressibility; susceptible to sliding on steep slopes; slopes as much as 30 percent.	Severe: slopes generally more than 10 percent.
Moderately slow permeability; high water table.	Moderately slow permeability; high water table; high available water capacity.	Poorly drained; poor workability; high shrink-swell potential.	Poorly drained; poor workability.	Poorly drained; high shrink-swell potential; low shear strength.	Severe: poorly drained.
Moderately slow permeability.	Moderately slow permeability; slopes as much as 10 percent.	Poor workability; high shrink-swell potential.	Poor workability; high shrink-swell potential.	High shrink-swell potential; low shear strength; moderately well drained; slopes as much as 10 percent.	Severe: moderately well drained; moderately slow permeability.
Moderately slow permeability.	Moderately slow permeability; stoniness; slopes as much as 12 percent.	Poor workability; high shrink-swell potential.	Poor workability; high shrink-swell potential; stoniness.	High shrink-swell potential; low shear strength; moderately well drained; stoniness; slopes as much as 12 percent.	Severe: moderately well drained; moderately slow permeability.
(2)	Stoniness; slopes as much as 25 percent; erodible.	Stoniness; slopes as much as 25 percent; erodible; susceptible to siltation.	Stoniness; slopes as much as 25 percent; susceptible to siltation of channels; difficult to establish plants.	Stoniness; slopes as much as 25 percent; moderate compressibility.	Severe: stoniness; slopes generally more than 10 percent.

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TABLE 3.—*Engineering*

Soil series and map symbols	Suitability as a source of—		Soil features affecting—		
	Topsoil	Road fill	Highway location	Farm ponds	
				Reservoir areas	Embankments
Olelo: OFC	Fair: low fertility.	Good: high shear strength; good compaction characteristics.	Slopes as much as 15 percent; high bearing capacity.	Slopes as much as 15 percent: moderately rapid permeability.	(4)
Oli: OID, OMB, OME, OMF.	Fair: low fertility	Fair: erodible; unstable on steep slopes.	Slopes as much as 70 percent.	Slopes as much as 70 percent; moderately rapid permeability.	Poor stability; poor compaction characteristics; erodible; subject to piping.
Olinda: ONC, OND, ONE.	Good	Fair: high organic-matter content; fair compaction characteristics.	Slopes as much as 40 percent; low shear strength; moderate compressibility.	Slopes as much as 40 percent; moderately rapid permeability.	Low shear strength; low compacted density; moderate compressibility.
Olokui: OOE	Poor: always wet; very low fertility.	Poor: poor compaction.	Wetness; low bearing capacity; subject to seepage.	Wetness; high seepage rate.	Poor compaction characteristics; wetness; low shear strength.
Opihikao: OPD	Poor: bedrock at a depth of less than 10 inches; extremely rocky.	Poor: organic material; bedrock at a depth of less than 10 inches.	Bedrock at a depth of less than 10 inches.	Bedrock at a depth of less than 10 inches.	(2)
Paaiki: PGE, PGF	Fair: low fertility.	Fair: unstable on steep slopes; erodible.	Slopes as much as 70 percent.	Moderately rapid permeability; slopes as much as 70 percent.	Poor stability; erodible; subject to piping.
Paaloa: PaC, PbC	Fair: low fertility.	Good	(3)	Moderately rapid permeability; slopes as much as 12 percent.	(4)
Paia: PcB, PcC, PcC2	Good	Good	Slopes as much as 15 percent.	Moderate permeability; slopes as much as 15 percent.	(3)
Pakala:					
PdA, PdC	Good	Good	Subject to local flooding.	Moderate permeability; slopes as much as 10 percent.	Erodible where exposed.
PHXC	Good, except stony.	Good, except stony.	Subject to local flooding; stoniness.	Moderate permeability; stoniness.	Stoniness; erodible where exposed.
Pamoa: PID, PID2, PJD2.	Fair: very sticky and very plastic.	Poor: highly plastic; poor workability; high shrink-swell potential.	High shrink-swell potential; low shear strength; slopes as much as 20 percent.	High shrink-swell potential; moderately slow permeability.	High shrink-swell potential; low shear strength; poor workability.
Pane: PXD	Good	Fair: low compacted density; moderate compressibility.	Slopes as much as 25 percent; moderate compressibility.	Slopes as much as 25 percent; moderately rapid permeability.	Low compacted density; moderate shear strength.

See footnotes at end of table.

interpretations—Continued

Soil features affecting—Continued					Degree and kind of limitations for septic tank filter fields
Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	Foundations for low buildings [1]	
(2)	(2)	(3)	Slopes as much as 15 percent.	Slopes as much as 15 percent; high shear strength.	Moderate: slopes generally more than 7 percent.
(2)	Slopes as much as 70 percent; erodible.	Slopes as much as 70 percent; erodible; susceptible to siltation.	Slopes as much as 70 percent; susceptible to siltation of channels.	Slopes as much as 70 percent.	Moderate on slopes of 3 to 10 percent; severe on slopes of more than 10 percent.
(2)	Slopes as much as 40 percent; modererately rapid permeability.	Slopes as much as 40 percent; erodible.	Slopes as much as 40 percent; erodible.	Slopes as much as 40 percent; moderate compressibility; low shear strength.	Moderate on slopes of 4 to 12 percent; severe on slopes of more than 12 percent.
(2)	(2)	(2)	(2)	Low shear strength; wetness; moderate compressibility; subject to seepage.	Severe: always wet; poorly drained; subject to seepage.
(2)	Bedrock at a depth of less than 10 inches; organic material.	(2)	(2)	Bedrock at a depth of less than 10 inches.	Severe: less than 10 inches of soil material over bedrock.
(2)	Slopes as much as 70 percent; moderately rapid permeability.	Slopes as much as 70 percent; erodible.	Slopes as much as 70 percent.	Slopes as much as 70 percent; susceptible to sliding on steep slopes.	Severe: slopes generally more than 10 percent.
(2)	Moderately rapid permeability; slopes as much as 12 percent.	(3)	Slopes as much as 12 percent.	Slopes as much as 12 percent.	Moderate: slopes generally 5 to 10 percent.
(2)	Moderate permeability; slopes as much as 15 percent.	(3)	Slopes as much as 15 percent; difficult to establish plants.	Slopes as much as 15 percent.	Slight on slopes of 3 to 7 percent; moderate on slopes of 7 to 15 percent.
(2)	Slopes as much as 10 percent; moderate permeability.	(3)	Difficult to establish plants; slopes as much as 10 percent.	Subject to local flooding; high bearing capacity; slopes as much as 10 percent.	Slight on slopes of 0 to 2 percent; moderate on slopes of 2 to 10 percent.
(2)	Stoniness; slopes as much as 12 percent.	Stoniness	Stoniness; difficult to establish plants; slopes as much as 12 percent.	Stoniness; subject to local flooding; slopes as much as 12 percent.	Moderate: slopes generally more than 5 percent; stoniness.
(2)	Slopes as much as 20 percent; moderately slow permeability.	High shrink-swell potential; poor workability.	Poor workability; slopes as much as 20 percent; difficult to establish plants.	High shrink-swell potential; low shear strength; slopes as much as 20 percent.	Severe: moderately slow permeability in subsoil; slopes generally more than 10 percent.
(2)	Slopes as much as 25 percent; moderately rapid permeability; rapid intake rate.	Slopes as much as 25 percent.	Slopes as much as 25 percent.	Moderate compressibility; moderate shear strength; slopes as much as 25 percent.	Severe: slopes generally more than 10 percent.

TABLE 3.—*Engineering*

Soil series and map symbols	Suitability as a source of— Topsoil	Road fill	Soil features affecting— Highway location	Farm ponds: Reservoir areas	Farm ponds: Embankments
Papaa: PYD, PYE, PYF	Poor: very sticky and very plastic.	Poor: very plastic; high shrink-swell potential.	Very plastic; high shrink-swell potential; slopes as much as 70 percent.	High shrink-swell potential; slow permeability; slopes as much as 70 percent.	Low shear strength; very plastic; high shrink-swell potential.
Paumalu: PeB, PeC, PeD, PeE, PeF, PZ. For Badland part of PZ, see Badland.	Fair: low fertility.	Good	Slopes as much as 70 percent.	Moderately rapid permeability; slopes as much as 70 percent.	(4)
Pauwela: PfB, PfC, PfD	Fair: low fertility.	Good	Slopes as much as 25 percent.	Moderately rapid permeability; slopes as much as 25 percent.	(4)
Pearl Harbor: Ph	Poor: wet; very sticky and very plastic.	Poor: very poorly drained; high shrink-swell potential; poor workability.	High shrink-swell potential; very poorly drained; low bearing capacity.	Very poorly drained; very slow permeability; high water table.	High shrink-swell potential; very poorly drained; poor workability.
Pohakupu: PkB, PkC	Good	Good	Slopes as much as 15 percent.	Moderately rapid permeability; slopes as much as 15 percent.	(8)
Pooku: PlB, PlD, PmB, PmC, PmD, PmE.	Poor: low fertility.	Good	Slopes as much as 40 percent.	Moderately rapid permeability; slopes as much as 40 percent.	(4)
Puhi: PnA, PnB, PnC, PnD, PnE.	Fair; low fertility	Good	Slopes as much as 40 percent.	Moderately rapid permeability; slopes as much as 40 percent.	High shear strength; high compacted density.
Pulehu: PoB, PpA, PpB, PrA, PrB, PsA, PtA, PtB, PuB.	Good	Good	Subject to flooding in low areas.	Moderate permeability; subject to to flooding in low areas.	Good compaction characteristics; high shear strength.
PoaB, PvC	Good, except stony.	Good, except stony.	Subject to flooding in low areas.	Moderate permeability; subject to flooding in low areas.	Good compaction characteristics; high shear strength; stoniness.

See footnotes at end of table.

interpretations—Continued

Soil features affecting—Continued					Degree and kind of limitations for septic tank filter fields
Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	Foundations for low buildings [1]	
(2)	Slow intake rate; slopes as much as 70 percent.	Poor workability; high shrink-swell potential; slopes as much as 70 percent.	Poor workability; slopes as much as 70 percent.	High shrink-swell potential; low shear strength; slopes as much as 70 percent; susceptible to sliding where slopes are more than 15 percent.	Severe: slow permeability; slopes generally more than 10 percent.
(2)	Moderately rapid permeability; slopes as much as 70 percent.	Slopes as much as 70 percent.	Slopes as much as 70 percent.	Slopes as much as 70 percent; moderate shrink-swell potential in surface layer.	Slight on slopes of 3 to 8 percent; moderate on slopes of 8 to 15 percent; severe on slopes of more than 15 percent.
(2)	(2)	Clayey; slopes as much as 25 percent.	Clayey; slopes as much as 25 percent.	Slopes as much as 25 percent.	Slight on slopes of 0 to 7 percent; moderate on slopes of 7 to 15 percent: severe on slopes of more than 15 percent.
Very slow permeability; high water table.	High water table; very slow permeability.	High water table; high shrink-swell potential; poor workability.	High water table; poor workability; high shrink-swell potential.	High water table; high shrink-swell potential; low bearing capacity.	Severe: very poorly drained; very slow permeability.
(2)	Slopes as much as 15 percent; moderately rapid permeability.	(3)	Slopes as much as 15 percent.	High shear strength; slopes as much as 15 percent.	Slight on slopes of 0 to 8 percent; moderate on slopes of 8 to 15 percent.
(2)	(2)	Slopes as much as 40 percent; moderately rapid permeability; low fertility.	Slopes as much as 40 percent; low fertility.	Slopes as much as 40 percent.	Slight on slopes of 0 to 8 percent; moderate on slopes of 8 to 15 percent; severe on slopes of more than 15 percent.
(2)	Slopes as much as 40 percent; moderately rapid permeability.	Slopes as much as 40 percent.	Slopes as much as 40 percent.	Slopes as much as 40 percent.	Slight on slopes of 0 to 8 percent; moderate on slopes of 8 to 15 percent; severe on slopes of more than 15 percent.
(2)	Slopes as much as 7 percent; moderate permeability.	Subject to stream overflow in low areas.	Slopes as much as 7 percent.	High shear strength; subject to flooding in low areas.	Slight on slopes of 0 to 7 percent; moderate in low areas; subject to occasional flooding.
(2)	Slopes as much as 12 percent; stoniness.	Subject to stream overflow in low areas; stoniness.	Slopes as much as 12 percent; stoniness.	High shear strength; subject to flooding in low areas; stoniness.	Slight on slopes of 0 to 7 percent; moderate on slopes of 7 to 12 percent.

TABLE 3.—*Engineering*

Soil series and map symbols	Suitability as a source of—		Soil features affecting—		
	Topsoil	Road fill	Highway location	Farm ponds	
				Reservoir areas	Embankments
Puuone: PZUE	Poor: low fertility; low available water capacity; cemented sand below a depth of 20 to 40 inches.	Poor: unstable on slopes erodible; cemented sand below a depth of 20 to 40 inches.	Slopes as much as 30 percent; unstable; erodible.	Slopes as much as 30 percent; shallow over cemented sand; rapid permeability above and below cemented sand.	Sandy material; rapid seepage rate; subject to piping; poor stability.
Puu Opae: PwC, PwD, PwE.	Fair: low fertility.	Good	Slopes as much as 40 percent.	Slopes as much as 40 percent; moderately rapid permeability.	(3)
Puu Pa: PZVE	Poor: stony; limited soil material.	Fair: erodible; unstable on steep slopes; slopes as much as 40 percent; stony.	Slopes as much as 40 percent; stoniness.	Slopes as much as 40 percent; moderately rapid permeability.	Poor compaction; piping hazard; stoniness.
Tantalus: TAE, TAF, TCC, TCE.	Fair to a depth of 15 inches: low fertility.	Fair: low compacted density; moderate compressibility.	Slopes as much as 70 percent; moderate compressibility; unstable on steep slopes.	Slopes as much as 70 percent; moderately rapid permeability.	Low compacted density; fine cinders below a depth of 15 to 36 inches.
Tropaquepts: TR	Poor: always wet.	Poor: always wet.	Wetness; poor workability.	High water table; slow permeability.	Poor workability; wetness.
Tropaquods: rTO	Poor: always wet.	Poor: always wet; accessibility is difficult.	Wetness; organic material.	Wetness; organic material.	(2)
Tropohumults: rTP For Dystrandepts part of rTP, see Dystrandepts.	Good	Good	Slopes as much as 90 percent.	Slopes as much as 90 percent; moderately rapid permeability.	Slopes as much as 90 percent.
Ulupalakua: ULD	Good to a depth of 24 inches; poor below 24 inches.	Fair: moderate compressibility; low compacted density.	Slopes as much as 25 percent; moderate compressibility.	Slopes as much as 25 percent; moderately rapid permeability.	Low compacted density; fine gravel-size cinders at a depth of 24 to 40 inches.
Uma: UME, UMF, URD.	Fair: low available water capacity; erodible; unstable on steep slopes.	Unstable on steep slopes; erodible; moderate compacted density.	Slopes as much as 70 percent; unstable on steep slopes; erodible.	Very high seepage rate; slopes as much as 70 percent.	Unstable on slopes; high erodibility; poor compaction characteristics.
Uwala: UwB, UwC, UwC3.	Good	Good	Slopes as much as 15 percent.	Slopes as much as 15 percent; moderate permeability.	(3)

See footnotes at end of table.

interpretations—Continued

Soil features affecting—Continued					Degree and kind of limitations for septic tank filter fields
Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	Foundations for low buildings [1]	
(2)	Rapid intake rate; low available water capacity; slopes as much as 30 percent.	Sandy material; erodible; slopes as much as 30 percent.	Erodible; slopes as much as 30 percent; difficult to establish plants.	Slopes as much as 30 percent; cemented sand at a depth of 20 to 40 inches.	Severe: 20 to 40 inches to cemented sand; slopes generally more than 10 percent.
(2)	Slopes as much as 40 percent; moderately rapid permeability.	All features favorable where slopes are not more than 20 percent.	Slopes as much as 40 percent.	Slopes as much as 40 percent; high shear strength.	Moderate on slopes of 8 to 15 percent; severe on slopes of more than 15 percent.
(2)	Stoniness; slopes as much as 40 percent; erodible.	Stoniness; slopes as much as 40 percent; erodible; susceptible to siltation.	Stoniness; slopes as as much 40 percent; susceptible to siltation; difficult to establish plants.	Stoniness: slopes as much as 40 percent; moderate compressibility.	Severe: slopes generally more than 10 percent; stoniness.
(2)	Slopes as much as 70 percent; moderately rapid permeability; rapid intake rate.	Slopes as much as 70 percent; fine cinders below a depth of 15 to 36 inches.	Slopes as much as 70 percent; fine cinders below a depth of 15 to 36 inches.	Moderate compressibility; slopes as much as 70 percent; susceptible to sliding.	Severe: slopes generally more than 10 percent; lack of filter material.
Slow permeability; high water table.	Poorly drained; slow permeability; high water table.	Poor workability; high water table.	Poorly drained; high water table.	Slow permeability; high water table; low shear strength.	Severe: high water table.
(2)	(2)	(2)	(2)	Wetness; moderate to high compressibility.	Severe: always wet.
(2)	Slopes as much as 90 percent.	(2)	Slopes as much as 90 percent.	Slopes as much as 90 percent.	Severe: slopes more than 30 percent.
(2)	Slopes as much as 25 percent; moderately rapid permeability; rapid intake rate.	Slopes as much as 25 percent; fine gravel-size cinders at a depth of 24 to 40 inches.	Slopes as much as 25 percent; fine gravel-size cinders at a depth of 24 to 40 inches.	Moderate compressibility; moderate shear strength; slopes as much as 25 percent.	Severe: slopes generally more than 10 percent; lack of filter material.
(2)	Very high intake rate; rapid permeability; slopes as much as 70 percent; erodible.	Slopes as much as 70 percent; erodible; fine gravel-size cinders at a depth of less than 10 inches.	Slopes as much as 70 percent; fine gravel-size cinders at a depth of less than 10 inches; difficult to establish plants.	Unstable on slopes; erodible; slopes as much as 70 percent.	Severe: slopes more than 15 percent; lack of filter material.
(2)	Slopes as much as 15 percent; moderate permeability.	Slopes as much as 15 percent; susceptible to siltation.	Susceptible to siltation of channels; slopes as much as 15 percent; difficult to establish plants.	Slopes as much as 15 percent.	Slight on slopes of 2 to 7 percent; moderate on slopes of 7 to 15 percent.

TABLE 3.—*Engineering*

Soil series and map symbols	Suitability as a source of—		Soil features affecting—		
	Topsoil	Road fill	Highway location	Farm ponds	
				Reservoir areas	Embankments
Wahiawa: WaA, WaB, WaC, WaD2.	Good	Good	All features favorable, except where slopes are as much as 25 percent.	Moderately rapid permeability; slopes as much as 25 percent.	(3)
Wahikuli: WbB, WcB	Fair to good: stony in places; bedrock at a depth of 20 to 40 inches.	Fair to good: stony in places; bedrock at a depth of 20 to 40 inches.	Bedrock at a depth of 20 to 40 inches; slopes as much as 15 percent.	Moderate permeability; bedrock at a depth of 20 to 40 inches; slopes as much as 15 percent.	Bedrock at a depth of 20 to 40 inches; stoniness in places.
Waiakoa: WeB, WeC, WfB, WgB, WgC, WhB, WhC, WlD2.	Good, except cobbly or stony in places.	Good, except cobbly or stony in places.	Bedrock at a depth of 20 to 40 inches; slopes as much as 25 percent; cobbly or stony in places.	Moderate permeability; bedrock at a depth of 20 to 40 inches.	Poor stability; piping hazard; bedrock at a depth of 20 to 40 inches.
Waialeale: rWAF	Poor: always wet; saprolite below a depth of 10 to 22 inches.	Poor: always wet; low shear strength; low bearing capacity.	Wetness; low shear strength; slopes as much as 70 percent.	Slopes of 30 to 70 percent; high seepage rate.	Wetness; poor compaction characteristics; low shear strength.
Waialua: WkA, WkB, W B, WlE, WmD, WnB.	Fair: very sticky and very plastic; stony in places.	Poor: very sticky and very plastic; moderate shrink-swell potential; stony in places.	Moderate shrink-swell potential; low shear strength; slopes as much as 30 percent; stony in places.	Moderate permeability; moderate shrink-swell potential; slopes as much as 30 percent.	Moderate shrink-swell potential; low shear strength; stoniness in places.
Waiawa: WJF	Very poor: very sticky and very plastic; rocky; less than 20 inches deep.	Very poor: very sticky and very plastic; rocky; bedrock at a depth of less than 20 inches.	Slopes 30 to 80 percent; bedrock at a depth of less than 20 inches; high shrink-swell potential; rockiness.	(2)	High shrink-swell potential; limited material; rockiness; low shear strength.
Waihuna: WoA, WoB, WoC, WoD, WohB.	Poor: very sticky and very plastic.	Poor: high shrink-swell potential; very sticky and very plastic.	High shrink-swell potential; slopes as much as 25 percent; low shear strength.	High shrink-swell potential; slopes as much as 25 percent; moderately slow permeability.	High shrink-swell potential; clayey; low shear strength.
Waikane: WpB, WpC, WpE, WpF, WpF2, WpaE.	Fair: low fertility; stony in places.	Good	Slopes as much as 70 percent; stony in places.	Slopes as much as 70 percent; moderately rapid permeability.	(4)

See footnotes at end of table.

interpretations—Continued

Soil features affecting—Continued					Degree and kind of limitations for septic tank filter fields
Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	Foundations for low buildings [1]	
(2)	Moderately rapid permeability; slopes as much as 25 percent.	All features favorable where slopes are less than 20 percent.	Slopes as much as 25 percent.	Slopes as much as 25 percent; high shear strength.	Slight on slopes of 0 to 8 percent; moderate on slopes of 8 to 15 percent; severe on slopes of more than 15 percent.
(2)	Moderate permeability; slopes as much as 15 percent; stoniness in places.	Bedrock at a depth of 20 to 40 inches; stoniness in places.	Bedrock at a depth of 20 to 40 inches; slopes as much as 15 percent; stoniness in places.	Bedrock at a depth of 20 to 40 inches; slopes as much as 15 percent; stoniness in places.	Severe: bedrock at a depth of less than 40 inches.
(2)	Erodible; slopes as much as 25 percent; bedrock at a depth of 20 to 40 inches.	Susceptible to siltation; bedrock at a depth of 20 to 40 inches; cobbly or stony in places.	Susceptible to siltation of channels; difficult to establish plants; slopes as much as 25 percent; cobbly or stony in places.	Slopes as much as 25 percent; bedrock at a depth of 20 to 40 inches.	Severe: bedrock at a depth of 20 to 40 inches.
Wetness; saprolite at a depth of 10 to 22 inches.	(2)	Slopes of 30 to 70 percent; wetness.	Slopes of 30 to 70 percent; wetness.	Slopes of 30 to 70 percent; wetness; low shear strength; susceptible to sliding.	Severe: slopes 30 to 70 percent; always wet; saprolite at a depth of 10 to 22 inches.
Moderate permeability.	Moderate permeability; slopes as much as 30 percent; stoniness in places.	Moderate shrink-swell potential; clayey; stoniness in places.	Slopes as much as 30 percent; stoniness in places.	Moderate shrink-swell potential; low shear strength; stoniness in places.	Slight on slopes of 0 to 8 percent; moderate permeability. Moderate on slopes of 8 to 15 percent; severe on slopes of more than 15 percent.
(2)	(2)	(2)	(2)	High shrink-swell potential; susceptible to sliding; slopes of 30 to 80 percent; rockiness; low shear strength.	Severe: bedrock at a depth of less than 20 inches; slopes of 30 to 80 percent.
Moderately slow permeability.	Slow intake rate; slopes as much as 25 percent; moderately slow permeability.	Clayey; high shrink-swell potential; slopes as much as 25 percent.	Clayey; slopes as much as 25 percent.	High shrink-swell potential; low shear strength; slopes as much as 25 percent.	Severe: moderately slow permeability.
(2)	(2)	All features favorable where slopes are less than 20 percent.	Slopes as much as 70 percent.	Slopes as much as 70 percent.	Slight on slopes of 3 to 8 percent; moderate on slopes of 8 to 15 percent; severe on slopes of more than 15 percent.

TABLE 3.—*Engineering*

Soil series and map symbols	Suitability as a source of—		Soil features affecting—		
	Topsoil	Road fill	Highway location	Farm ponds	
				Reservoir areas	Embankments
Waikapu: WrA, WrB, WrB3, WrC3.	Good	Good	Slopes as much as 15 percent.	Moderate permeability.	([3])
Waikomo: Ws, Wt, Wu	Poor: bedrock at a depth of less than 20 inches; stony and rocky.	Poor: bedrock at a depth of less than 20 inches; stony and rocky.	Bedrock at a depth of less than 20 inches; stoniness and rockiness.	Bedrock at a depth of less than 20 inches; moderate permeability.	Stoniness; rockiness; limited volume of material; bedrock at a depth of less than 20 inches.
Wailuku: WvB, WvC, WwC.	Good	Good	Slopes as much as 15 percent.	Slopes as much as 15 percent; moderate permeability.	([3])
Wainee: WxB, WxC, WyB, WyC.	Poor: stony; limited volume of soil material.	Poor: stony; limited volume of soil material.	Stoniness; slopes as much as 15 percent.	Stoniness; slopes as much as 15 percent; moderately rapid permeability.	Stoniness; limited volume of soil material.
Waipahu: WzA, WzB, WzC.	Fair: sticky and plastic.	Poor: high shrink-swell potential; poor workability; low shear strength.	High shrink-swell potential; low shear strength; slopes as much as 12 percent.	Moderately slow permeability; high shrink-swell potential.	High shrink-swell potential; low shear strength.

[1] Engineers and others should not apply specific values to the estimates given for bearing capacity of soils.
[2] Practice not applicable or not needed.

interpretations—Continued

Soil features affecting—Continued					Degree and kind of limitations for septic tank filter fields
Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	Foundations for low buildings [1]	
(2)	Slopes as much as 15 percent; moderate permeability.	Susceptible to siltation.	Susceptible to siltation of channels; difficult to establish plants; slopes as much as 15 percent.	Slopes as much as 15 percent.	Slight on slopes of 0 to 7 percent; moderate on slopes of 7 to 15 percent.
(2)	Bedrock at a depth of less than 20 inches; stoniness and rockiness.	Bedrock at a depth of less than 20 inches; stoniness and rockiness.	Bedrock at a depth of less than 20 inches; stoniness and rockiness.	Bedrock at a depth of less than 20 inches; stoniness and rockiness.	Severe: bedrock at a depth of less than 20 inches.
(2)	Moderate permeability; slopes as much as 15 percent.	Slopes as much as 15 percent.	Slopes as much as 15 percent.	Slopes as much as 15 percent.	Slight on slopes of 3 to 7 percent; moderate on slopes of 8 to 15 percent.
(2)	Stoniness; slopes as much as 15 percent.	Stoniness; slopes as much as 15 percent.	Stoniness; slopes as much as 15 percent.	Stoniness; slopes as much as 15 percent.	Slight on slopes of 3 to 7 percent; moderate on slopes of 7 to 15 percent.
Moderately slow permeability.	Moderately slow permeability; slopes as much as 12 percent.	Clayey; slopes as much as 12 percent.	Difficult to establish plants; slopes as much as 12 percent.	Low shear strength; high shrink-swell potential; slopes as much as 12 percent.	Severe: moderately slow permeability; slopes as much as 12 percent.

[3] All features favorable.
[4] Under field conditions, it is difficult to reduce moisture content to that required for favorable compaction.

TABLE 4.—*Engineering test data*

[Tests were performed by the Bureau of Public Roads]

Soil name and location	Parent material	BPR report number	Depth	Mechanical analysis: Percentage passing sieve— No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)	Percentage smaller than— 0.05 mm.	0.02 mm.	0.005 mm.	0.002 mm.	Liquid limit	Plasticity index	Classification: AASHO	Unified
		S44-	*In.*								*Pct.*			
Lualualei clay: 0.08 mile west of entrance gate to Lualualei Naval Radio Station and southwest along fence, 100 feet north toward radio tower. Island of Oahu.	Alluvium from basic igneous rock.	790	1–10	-----	-----	99	97	91	81	73	60	30	A–7–6(20)	MH
		791	22–30	-----	-----	99	98	92	82	74	76	49	A–7–6(20)	CH
Molokai silty clay loam: One mile southwest of Kualapuu in block 4, 0.32 mile northeast of junction 47 and east of Highway 47. Island of Molokai.	Basic igneous rock.	784	0–11	100	100	92	89	80	62	52	44	16	A–7–6(11)	ML–CL
		785	37–63	100	97	85	80	62	41	33	46	16	A–7–5(12)	ML
Naiwa silty clay loam: 1.45 miles north of Waihee School, 0.2 mile west and 0.3 mile south on trail up side of hill. Island of Maui.	Basic igneous rock.	780	0–4	100	98	94	92	82	64	36	40	8	A–4(8)	ML
		781	14–26	100	99	97	97	96	96	83	36	7	A–4(8)	ML
Wahiawa silty clay: 0.5 mile southeast of Waipio. Island of Oahu.	Basic igneous rock.	798	0–16	100	98	92	91	89	86	81	62	24	A–7–5(18)	MH
		799	32–60	-----	-----	-------	100	99	98	94	68	29	A–7–5(20)	MH

The USDA texture is the apparent field texture. By standards of mechanical analysis, most soils described in this survey are clay.

Permeability refers only to movement of water downward through undisturbed and uncompacted soil. It does not include lateral seepage. The estimates are based on soil structure, soil porosity, and data from a limited number of permeability tests made on undisturbed cores. Plowpans, surface crusts, and other properties resulting from use of the soils were not considered.

Estimated available water capacity is an estimate of the capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil. The estimates are based on extensive laboratory tests, on field experience, and on soil properties.

Reaction is the degree of acidity or alkalinity of a soil, expressed as a pH value. The pH value and relative terms used to describe soil reaction are explained in the Glossary.

Shrink-swell potential is an indication of the volume change to be expected of the soil material with changes in moisture content. A high shrink-swell potential indicates hazards to the maintenance of structures constructed in, on, or with such materials. Generally, soils classified CH have a high shrink-swell potential, and those classified ML or SP have a low shrink-swell potential. Many of the soils classified OH occur in high rainfall areas and are continuously wet throughout the year. These soils exhibit high shrinkage and low swell potential when placed in a dry environment.

Corrosivity, as used here, indicates the potential danger to uncoated metal or concrete structures through chemical action that dissolves or weakens the structural material. Structural material may corrode when buried in soil, and a given material corrodes in some kinds of soil more rapidly than in others. Extensive installations that intersect soil boundaries or soil horizons are more likely to be damaged by corrosion than are installations entirely in one kind of soil or soil horizon.

Engineering interpretations

Table 3 contains information useful to engineers and others who plan to use soil material in construction of highways, farm facilities, buildings, and sewage disposal systems. Detrimental or undesirable features are emphasized, but some of the important desirable features are

also listed. The ratings and other interpretations in this table are based on estimated engineering properties shown in table 2, on available test data, and on field experience. Although the information applies only to the soil depths indicated in table 2, it is reasonably reliable to a depth of about 6 feet in most soils and several more for some.

The Jaucas and Puuone soils, the subsoil of the Mokuleia soils, Beaches, and Dune land are good sources of calcareous sand. Crushed hard rock or coral is the best source of gravel, but there are a few sources of gravel adjacent to intermittent streams associated with Kawaihapai and Pulehu soils.

Topsoil is used to designate a fertile soil or soil material, ordinarily rich in organic-matter content, used as a topdressing for lawns, gardens, and roadbanks. The ratings indicate suitability for such use. Soils that have low inherent fertility are rated according to their response to fertilization.

Road fill refers to material used to build embankments. The ratings indicate performance of soil material moved from borrow areas for these purposes.

Highway location is influenced by features of the undisturbed soil that affect construction and maintenance of highways. The soil features described, favorable as well as unfavorable, are the principal ones that affect location of highways.

Farm pond reservoir areas are affected mainly by loss of water through seepage, and the soil features described are those that influence such seepage.

Farm pond embankments serve as dams. The soil features given, of both subsoil and substratum, are those important in the use of the soils for constructing embankments.

Agricultural drainage is affected by permeability, texture, structure, depth to the water table, and other soil properties that affect the installation and performance of surface and subsurface drainage structures.

Irrigation is affected by texture, structure, permeability, available water capacity, slope, and other soil factors that influence suitability for irrigation.

Foundations for low buildings are affected chiefly by features of the undisturbed soil that influence the capacity of the soil to support low buildings that have a normal foundation load. Specific values of bearing strength are not given or implied.

Septic tank filter fields are affected mainly by permeability, depth to the water table, susceptibility to flooding, depth to bedrock, and slope. The degree and the principal kinds of limitations are given.

Engineering test data

Table 4 shows the results of engineering tests performed by the Bureau of Public Roads on important soils on the islands of Oahu, Maui, and Molokai. The table shows the specific location where samples were taken, the depth to which sampling was done, and the results of tests to determine particle-size distribution and other properties significant in soil engineering.

Mechanical analysis shows the percentages, by weight, of soil particles that pass sieves of specified sizes. Sand and other coarser materials do not pass through the No. 200 sieve, but silt and clay do. Silt is that material larger than 0.002 millimeter in diameter that passes through the No. 200 sieve, and clay is that fraction smaller than 0.002 millimeter in diameter that passes through the No. 200 sieve. The clay fraction was determined by the hydrometer method.

Liquid limit and plasticity index indicate the effect of water on the strength and consistence of soil material. As the moisture content of a clayey soil is increased from a dry state, the material changes from a semisolid to a plastic state. If the moisture content is further increased, the material changes from a plastic to a liquid state. The plastic limit is the moisture content at which the soil material passes from semisolid to plastic. The liquid limit is the moisture content at which the material changes from plastic to liquid. The plasticity index is the numerical difference between the liquid limit and the plastic limit. It indicates the range of moisture content within which a soil material is plastic.

Classification, Genesis, and Morphology of the Soils[5]

In this survey 127 soil series are described. To understand why there should be so many, it is necessary to picture the pattern of soils on the landscape and to understand the similarities and differences among soils. The pattern of soils is a result of the interaction of the factors of soil genesis: climate, vegetation, parent material, relief, and drainage, over a period of time. The similarities and differences among soils and the reasons for them can be examined by classifying the soils into groups.

Soils are classified according to their observable and measurable properties. The properties chosen are primarily those that permit the grouping of soils that are genetically similar. Soil classification enables us to understand the pattern of soils and the ways in which they relate to each other.

The scheme of classification used in this survey was adopted for general use by the National Cooperative Soil Survey in 1965 and supplemented in September 1968 (*17*). It replaces a system that was adopted in 1938 and later revised (*15, 14*). The system incorporates knowledge gained through research over the last 25 years and is much more precise and more complex than the older system. It is under continual study. Readers interested in the development of the system should refer to the latest literature available (*12*).

The current system of classification has six categories. Beginning with the most inclusive, these categories are the order, the suborder, the great group, the subgroup, the family, and the series. The placement of some soil series in the current system of classification, particularly in families, may change as more precise information becomes available.

Table 5 shows the classification of each soil series on the islands by family, by subgroup and great group, and by order, according to the current system. It also shows one category—the great soil group—of the 1938 system.

[5] By L. D. SWINDALE, associate director, Hawaii Agricultural Experiment Station, and professor of soil science, University of Hawaii, and members of the Soil Survey Correlation Staff.

TABLE 5.—*Classification of soil series by higher categories*

Series	Family	Subgroup and great group	Order	Great soil group (1938 classification)
Alae	Medial, isohyperthermic	Mollic Vitrandepts	Inceptisols	Alluvial soils.
Alaeloa	Clayey, oxidic, isohyperthermic	Orthoxic Tropohumults	Ultisols	Humic Ferruginous Latosols.
Alakai	Clayey, kaolinitic, dysic, isomesic	Terric Troposaprists	Histosols	Bog soils.
Amalu	Fine, mixed, acid, isomesic	Histic Placaquepts	Inceptisols	Hydrol Humic Latosols.
Ewa	Fine, kaolinitic, isohyperthermic	Aridic Haplustolls	Mollisols	Low-Humic Latosols.
Haiku	Clayey, ferritic, isothermic	Humoxic Tropohumults	Ultisols	Humic Ferruginous Latosols.
Halawa	Clayey, oxidic, isothermic	Orthoxic Tropohumults	Ultisols	Humic Ferruginous Latosols.
Haleiwa	Fine, mixed, isohyperthermic	Typic Haplustolls	Mollisols	Alluvial soils.
Halii	Clayey, ferritic, isothermic	Typic Gibbsihumox	Oxisols	Humic Ferruginous Latosols.
Haliimaile	Fine, kaolinitic, isothermic	Ustoxic Humitropepts	Inceptisols	Low-Humic Latosols.
Hamakuapoko	Clayey, oxidic, isothermic	Orthoxic Tropohumults	Ultisols	Low-Humic Latosols.
Hana	Thixotropic, isohyperthermic	Typic Hydrandepts	Inceptisols	Humic Latosols.
Hanalei	Fine, mixed, nonacid, isohyperthermic.	Typic Tropaquepts	Inceptisols	Alluvial soils.
Hanamaulu	Fine, oxidic, isohyperthermic	Oxic Humitropepts	Inceptisols	Humic Latosols.
Helemano	Clayey, kaolinitic, isohyperthermic	Tropeptic Haplustox	Oxisols	Low-Humic Latosols.
Hihimanu	Fine, oxidic, isothermic	Ustoxic Humitropepts	Inceptisols	Humic Latosols.
Holomua	Clayey, kaolinitic, isohyperthermic.	Typic Torrox	Oxisols	Low-Humic Latosols.
Honolua	Clayey, oxidic, isothermic	Humoxic Tropohumults	Ultisols	Humic Latosols.
Honomanu	Thixotropic, isothermic	Typic Hydrandepts	Inceptisols	Hydrol Humic Latosols.
Honouliuli	Very-fine, kaolinitic, isohyperthermic.	Typic Chromusterts	Vertisols	Gray Hydromorphic soils.
Hoolehua	Fine, kaolinitic, isohyperthermic	Aridic Haplustolls	Mollisols	Low-Humic Latosols.
Hulua	Fine, oxidic, acid, isothermic	Typic Placaquepts	Inceptisols	Gray Hydromorphic soils.
Iao	Fine, kaolinitic, isohyperthermic	Typic Haplustolls	Mollisols	Alluvial soils.
Io	Medial over cindery, isothermic	Typic Eutrandepts	Inceptisols	Reddish Prairie soils.
Ioleau	Clayey, oxidic, isohyperthermic	Orthoxic Tropohumults	Ultisols	Humic Ferruginous Latosols.
Jaucas	Carbonatic, isohyperthermic	Typic Ustipsamments	Entisols	Regosols.
Kaena	Very-fine, montmorillonitic, isohyperthermic.	Typic Pelluderts	Vertisols	Gray Hydromorphic soils.
Kahana	Clayey, kaolinitic, isothermic	Tropeptic Haplustox	Oxisols	Low-Humic Latosols.
Kahanui	Clayey, ferritic, isothermic	Petroferric Acrohumox	Oxisols	Humic Ferruginous Latosols.
Kailua	Thixotropic, isothermic	Typic Hydrandepts	Inceptisols	Hydrol Humic Latosols.
Kaimu	Euic, isohyperthermic	Typic Tropofolists	Histosols	Lithosols.
Kaipoioi	Medial, isomesic	Typic Dystrandepts	Inceptisols	Latosolic Brown Forest soils.
Kalae	Clayey, oxidic, isothermic	Typic Rhodustults	Ultisols	Humic Ferruginous Latosols.
Kalapa	Clayey, oxidic, isothermic	Humoxic Tropohumults	Ultisols	Humic Latosols.
Kalaupapa	Medial, isohyperthermic	Lithic Eutrandepts	Inceptisols	Reddish Prairie soils.
Kalihi	Very-fine, kaolinitic, nonacid, isohyperthermic.	Typic Tropaquepts	Inceptisols	Gray Hydromorphic soils.
Kaloko	Fine, carbonatic, isohyperthermic	Typic Haplaquolls	Mollisols	Gray Hydromorphic soils.
Kamaole	Clayey over fragmental, kaolinitic, isothermic.	Aridic Haplustolls	Mollisols	Reddish Brown soils.
Kaneohe	Clayey, oxidic, isothermic	Humoxic Tropohumults	Ultisols	Humic Latosols.
Kanepuu	Fine, oxidic, isothermic	Oxic Paleustalfs	Alfisols	Humic Ferruginous Latosols.
Kapaa	Clayey, gibbsitic, isothermic	Typic Gibbsihumox	Oxisols	Humic Ferruginous Latosols.
Kapuhikani	Very-fine, montmorillonitic, isohyperthermic.	Mollic Torrerts	Vertisols	Dark Magnesium Clays.
Kaupo	Fine-silty over fragmental, mixed, isohyperthermic.	Pachic Haplustolls	Mollisols	Humic Latosols.
Kawaihapai	Fine, mixed, isohyperthermic	Cumulic Haplustolls	Mollisols	Alluvial soils.
Keaau	Very-fine, montmorillonitic, nonacid, isohyperthermic.	Typic Tropaquepts	Inceptisols	Gray Hydromorphic soils.
Keahua	Clayey kaolinitic, isohyperthermic.	Typic Torrox	Oxisols	Low-Humic Latosols.
Kealia	Coarse-loamy, mixed, isohyperthermic.	Typic Salorthids	Aridisols	Solonchak.
Keawakapu	Clayey over fragmental, kaolinitic, isohyperthermic.	Aridic Haplustolls	Mollisols	Reddish Brown soils.
Kekaha	Very-fine, mixed, isohyperthermic	Cumulic Haplustolls	Mollisols	Low-Humic Latosols.
Kemoo	Fine, oxidic, isothermic	Oxic Rhodustalfs	Alfisols	Humic Ferruginous Latosols.
Koele	Fine, kaolinitic, isothermic	Aridic Haplustolls	Mollisols	Alluvial soils.
Kokee	Clayey, oxidic, isomesic	Humoxic Tropohumults	Ultisols	Humic Latosols.
Koko	Medial, isohyperthermic	Ustollic Eutrandepts	Inceptisols	Reddish Brown soils.
Kokokahi	Very-fine, montmorillonitic, isohyperthermic.	Udorthentic Pellusterts	Vertisols	Dark Magnesium Clays.
Kolekole	Fine, oxidic, isothermic	Ustoxic Humitropepts	Inceptisols	Humic Ferruginous Latosols.
Koloa	Clayey, kaolinitic, isohyperthermic, shallow.	Tropeptic Eutrustox	Oxisols	Low-Humic Latosols.
Kolokolo	Fine, mixed, isohyperthermic	Fluventic Humitropepts	Inceptisols	Alluvial soils.
Koolau	Fine, kaolinitic, acid, isothermic	Aeric Tropaquepts	Inceptisols	Gray Hydromorphic soils.

TABLE 5.—*Classification of soil series by higher categories*—Continued

Series	Family	Subgroup and great group	Order	Great soil group (1938 classification)
Kula	Medial, isothermic	Typic Eutrandepts	Inceptisols	Reddish Prairie soils.
Kunia	Fine, kaolinitic, isothermic	Ustoxic Humitropepts	Inceptisols	Low-Humic Latosols.
Kunuweia	Clayey, ferritic, isomesic	Plinthic Acrorthox	Oxisols	Humic Ferruginous Latosols.
Lahaina	Clayey, kaolinitic, isohyperthermic.	Typic Torrox	Oxisols	Low-Humic Latosols.
Laumaia	Medial, isomesic	Typic Dystrandepts	Inceptisols	Latosols Brown Forest soils.
Lawai	Very-fine, oxidic, isohyperthermic.	Oxic Humitropepts	Inceptisols	Humic Ferruginous Latosols.
Leilehua	Clayey, oxidic, isothermic	Humoxic Tropohumults	Ultisols	Humic Ferruginous Latosols.
Lihue	Clayey, kaolinitic, isohyperthermic.	Tropeptic Eutrustox	Oxisols	Low-Humic Latosols.
Lolekaa	Clayey, oxidic, isothermic	Humoxic Tropohumults	Ultisols	Humic Latosols.
Lualualei	Very-fine, montmorillonitic, isohyperthermic.	Typic Chromusterts	Vertisols	Dark Magnesium Clays.
Mahana	Medial, isothermic	Oxic Dystrandepts	Inceptisols	Humic Ferruginous Latosols.
Makaalae	Clayey-skeletal, mixed, isohyperthermic.	Ustic Humitropepts	Inceptisols	Humic Latosols.
Makalapa	Very-fine, montmorillonitic, isohyperthermic.	Typic Chromusterts	Vertisols	Dark Magnesium Clays.
Makapili	Clayey, ferritic, isothermic	Typic Acrohumox	Oxisols	Humic Ferruginous Latosols.
Makawao	Clayey,oxidic, isothermic	Humoxic Tropohumults	Ultisols	Humic Latosols.
Makaweli	Clayey, kaolinitic, isohyperthermic.	Typic Torrox	Oxisols	Low-Humic Latosols.
Makena	Coarse-loamy, ashy, isohyperthermic.	Aridic Haplustolls	Mollisols	Red Desert soils.
Makiki	Fine, mixed, isohyperthermic	Andic Ustic Humitropepts	Inceptisols	Low-Humic Latosols.
Mala	Fine, kaolinitic, nonacid, isohyperthermic.	Typic Torrifluvents	Entisols	Alluvial soils.
Malama	Dysic, isohyperthermic	Typic Tropofolists	Histosols	Lithosols.
Mamala	Clayey, kaolinitic, isohyperthermic.	Lithic Haplustolls	Mollisols	Low-Humic Latosols.
Manana	Clayey, oxidic, isothermic	Orthoxic Tropohumults	Ultisols	Humic Ferruginous Latosols.
Mokuleia	Sandy, carbonatic, isohyperthermic.	Entic Haplustolls	Mollisols	Alluvial soils.
Molokai	Clayey, kaolinitic, isohyperthermic.	Typic Torrox	Oxisols	Low-Humic Latosols.
Naiwa	Medial, isothermic	Oxic Dystrandepts	Inceptisols	Humic Ferruginous Latosols.
Niu	Clayey, kaolinitic, isohyperthermic.	Typic Torrox	Oxisols	Low-Humic Latosols.
Niulii	Thixotropic, isothermic	Hydric Dystrandepts	Inceptisols	Humic Latosols.
Nohili	Fine, montmorillonitic (calcareous), isohyperthermic.	Cumulic Haplaquolls	Mollisols	Gray Hydromorphic soils.
Nonopahu	Very-fine, kaolinitic, isohyperthermic.	Entic Chromusterts	Vertisols	Dark Magnesium Clays.
Oanapuka	Medial, isohyperthermic	Ustollic Eutrandepts	Inceptisols	Reddish Brown soils.
Olelo	Clayey, oxidic, isothermic	Humoxic Tropohumults	Ultisols	Humic Ferruginous Latosols.
Oli	Medial, isothermic	Oxic Dystrandepts	Inceptisols	Reddish Prairie soils.
Olinda	Medial, isomesic	Entic Dystrandepts	Inceptisols	Latosolic Brown Forest soils.
Olokui	Fine, mixed, acid, isomesic	Typic Placaquepts	Inceptisols	Gray Hydromorphic soils.
Opihikao	Dysic, isohyperthermic	Lithic Tropofolists	Histosols	Lithosols.
Paaiki	Medial, isothermic	Typic Dystrandepts	Inceptisols	Humic Latosols.
Paaloa	Clayey, oxidic, isothermic	Humoxic Tropohumults	Ultisols	Humic Latosols.
Paia	Fine, kaolinitic, isohyperthermic	Typic Haplustolls	Mollisols	Low-Humic Latosols.
Pakala	Fine, oxidic, isohyperthermic	Fluventic Ustropepts	Inceptisols	Alluvial soils.
Pamoa	Very-fine, kaolinitic, isohyperthermic.	Torrertic Haplustolls	Mollisols	Low-Humic Latosols.
Pane	Medial, isothermic	Typic Dystrandepts	Inceptisols	Reddish Prairie soils.
Papaa	Very-fine, montmorillonitic, isohyperthermic.	Udic Chromusterts	Vertisols	Dark Magnesium Clays.
Paumalu	Clayey, oxidic, isothermic	Humoxic Tropohumults	Ultisols	Humic Latosols.
Pauwela	Clayey, ferritic, isothermic	Humoxic Tropohumults	Ultisols	Humic Ferruginous Latosols.
Pearl Harbor	Fine, montmorillonitic, nonacid, isohyperthermic.	Typic Tropaquepts	Inceptisols	Gray Hydromorphic soils.
Pohakupu	Fine, oxidic, isohyperthermic	Ustoxic Humitropepts	Inceptisols	Humic Latosols.
Pooku	Clayey, ferritic, isothermic	Typic Acrohumox	Oxisols	Humic Ferruginous Latosols.
Puhi	Clayey, oxidic, isohyperthermic	Typic Umbriorthox	Oxisols	Humic Ferruginous Latosols.
Pulehu	Fine-loamy, mixed, isohyperthermic.	Cumulic Haplustolls	Mollisols	Alluvial soils.
Puuone	Carbonatic, isohyperthermic	Typic Ustipsamments	Entisols	Regosols.
Puu Opae	Clayey, oxidic, isothermic	Typic Rhodustults	Ultisols	Humic Ferruginous Latosols.
Puu Pa	Medial over fragmental, isothermic	Ustollic Eutrandepts	Inceptisols	Reddish Brown soils.
Tantalus	Medial over cindery, isothermic	Typic Dystrandepts	Inceptisols	Latosolic Brown Forest soils.

TABLE 5.—*Classification of soil series by higher categories*—Continued

Series	Family	Subgroup and great group	Order	Great soil group (1938 classification)
Ulupalakua	Medial over cindery, isothermic	Typic Eutrandepts	Inceptisols	Reddish Prairie soils.
Uma	Cindery, isomesic	Typic Vitrandepts	Inceptisols	Regosols.
Uwala	Clayey, kaolinitic, isothermic	Typic Torrox	Oxisols	Low-Humic Latosols.
Wahiawa	Clayey, kaolinitic, isothermic	Tropeptic Eutrustox	Oxisols	Low-Humic Latosols.
Wahikuli	Clayey, kaolinitic, isohyperthermic	Typic Torrox	Oxisols	Low-Humic Latosols.
Waiakoa	Fine, kaolinitic, isohyperthermic	Aridic Haplustolls	Mollisols	Low-Humic Latosols.
Waialeale	Fine, oxidic, isomesic	Histic Lithic Tropaquods	Spodosols	Gray Hydromorphic soils.
Waialua	Very-fine, kaolinitic, isohyperthermic.	Typic Haplustolls	Mollisols	Low-Humic Latosols.
Waiawa	Clayey, montmorillonitic, isohyperthermic.	Lithic Vertic Haplustolls	Mollisols	Lithosols.
Waihuna	Very-fine, kaolinitic, isothermic	Typic Chromusterts	Vertisols	Low-Humic Latosols.
Waikane	Clayey, oxidic, isothermic	Humoxic Tropohumults	Ultisols	Humic Latosols.
Waikapu	Clayey, kaolinitic, isohyperthermic	Typic Torrox	Oxisols	Low-Humic Latosols.
Waikomo	Clayey, mixed, isohyperthermic	Lithic Haplustolls	Mollisols	Reddish Brown soils.
Wailuku	Clayey, kaolinitic, isohyperthermic	Tropeptic Haplustox	Oxisols	Low-Humic Latosols.
Wainee	Clayey-skeletal, kaolinitic, isohyperthermic.	Aridic Haplustolls	Mollisols	Low-Humic Latosols.
Waipahu	Very-fine, kaolinitic, isohyperthermic.	Torrertic Haplustolls	Mollisols	Low-Humic Latosols.

ORDER.—There are 10 orders: Entisols, Vertisols, Inceptisols, Aridisols, Mollisols, Spodosols, Alfisols, Ultisols, Oxisols, and Histosols. All are represented on the islands.

An order represents the kind and the relative strength of the soil-forming process. Although it does not correspond exactly with any other category in any other classification system, each order is made up of certain well-recognized groups of soils.

Entisols, for example, are recent soils and very steep soils that lack distinctive horizons. *Vertisols* are dark-colored, clayey soils that swell and soils formerly classified as Tropical Black Earths. *Inceptisols* are soils that are on young but not recent land surfaces and have weakly developed horizons. *Aridisols* are soils that are generally dry. *Mollisols* are grassland soils, of subhumid regions, that have a deep, dark-colored, well-structured surface layer. *Spodosols* are Podzols and many hydromorphic soils. *Alfisols* are timbered soils, other than Podzols, of subhumid regions. *Ultisols* are timbered soils, other than Podzols, of humid regions. *Oxisols* are very strongly weathered soils and soils on very old tropical landscapes. *Histosols* are organic soils.

SUBORDER.—An order is so broad that the soils in it have similar morphology but little or no genetic relationship. Criteria used to divide orders into suborders have been chosen to produce categories of greater genetic homogeneity. For example, most orders contain well-drained soils and their associated poorly drained soils. The criteria for suborders reflect the absence or presence of wetness or differences in climate or vegetation.

GREAT GROUP.—Each suborder is divided into great groups on the basis of uniformity in kind and sequence of genetic horizons, on base saturation, or on properties related to climate. Each great group, therefore, is uniform in kind and arrangement of genetic horizons and features, and each is within a relatively narrow range of climate. Brief definitions of genetic horizons and such terms as "base saturation" are given in the Glossary.

SUBGROUP.—Each great group is divided into subgroups, one representing the central (typic) concept of the subgroup, and others, called intergrades, representing soils that have mostly the properties of one great group but also have one or more properties of another great group, suborder, or order. For example, if soils in a great group of the order Ultisols were considered to be intergrades toward the order Oxisols, they would be classified in an *Oxic* subgroup of the great group.

A few subgroups differ from the central, or typic, concept in having soils that have distinctive properties but indicate no intergradation toward other categories of the system. For example, some soils in a great group of the order Mollisols are subject to occasional flooding. Consequently, they accumulate soil material on the surface and have a distinctively thicker topsoil than the soils in the *Typic* subgroup. These aberrant soils would be classified in a *Cumulic* subgroup.

Several subgroups, particularly in the orders Inceptisols and Ultisols, correspond approximately to soil families according to the classification by Cline (*5*).

FAMILY.—Families are established within a subgroup on the basis of properties important to the growth of plants or the behavior of soils when they are used for engineering. Among the properties considered are texture, mineral composition, reaction, soil temperature, permeability, thickness of horizons, and consistence.

SERIES.—The series has the narrowest range of characteristics of the categories in the classification system. It is described fully in the section "How This Survey Was Made." Each soil series on the islands is described in detail in the section "Descriptions of the Soils."

Classification of the Soils on the Islands

The following pages tell how the soil series represented on the islands are classified by order and suborder.

Entisols

Entisols are recent soils that have little or no horizon development. The order includes almost all soils that are but little changed from the parent material in which they formed.

Two suborders of Entisols occur in Hawaii: Psamments and Fluvents. The prefix *Psamm*, derived from the Greek word for *sand*, indicates coarse texture. The prefix *Fluv* is derived from the Latin word *fluvius*, meaning *river*. It indicates the stratified nature of the soils. The suffix *ent* indicates the name of the order Entisols.

Psamments

Jaucas and Puuone soils are classified as Psamments. They formed in stabilized coral sand near beaches. They show very little soil development.

Jaucas and Puuone soils receive 10 to 40 inches of rainfall annually and have a mean annual soil temperature of about 75° F. They are sandy and excessively drained. The vegetation consists of bermudagrass, kiawe, koa haole, and lantana. The accumulation of organic matter accounts for the dark color of the calcareous sand in the surface soil. Because of the low rainfall, the high soil temperature, and the sandy texture, these soils are generally dry for 90 cumulative days or more, but for less than 6 months. Therefore, Jaucas and Puuone soils are placed in the great group of Ustipsamments; the prefix *Ust* indicates that the soils formed in a dry climate.

Jaucas and Puuone soils belong to the typic, or central, subgroup of this great group. Finally, they are placed in the carbonatic, isohyperthermic family. The first term in the family name applies to the mineralogy and the last to a mean annual soil temperature of more than 71.6° F.

Fluvents

Mala soils are classified as Fluvents. They receive 10 to 25 inches of rainfall annually and have a mean annual soil temperature of about 75° F. The A horizon is dark reddish-brown silty clay, and the C horizon stratified dark reddish-brown and very dark gray silty clay. The organic-matter content decreases irregularly within the profile. Because of low rainfall and high soil temperature, these soils are dry for more than 6 months in most years. Therefore, they belong in the typic, or central, subgroup. They are placed in the fine, kaolinitic, nonacid, isohyperthermic family of the Typic Torrifluvents because of the silty clay control section, the tabular halloysitic mineralogy, the slightly acid to mildly alkaline reaction, and the mean annual soil temperature of 74° F.

Vertisols

Vertisols are usually black or dark gray in color. They are high in clay, have poor structure, and develop large cracks when dry. The shrinking, cracking, and shearing make these soils difficult to manage for farming and for engineering and other nonfarm uses.

The order includes most of the Dark Magnesium soils and some of the Gray Hydromorphic soils, as classified by Cline (*5*).

In Hawaii, Vertisols occur along the coast in marine alluvium deposited when the sea stood much higher than it does now and in colluvium that consisted of fine clays and large stones. They occur on long fans that originate in the mountains and spill out over the coastal plains.

Vertisols contain a large amount of very fine clay, either the mineral montmorillonite or tabular halloysite. The clay shrinks and swells with changes in water content. The surface half inch of these soils is generally a layer of hard granules, which are evidence of excessive shrinkage of the clays in the sun's heat. The granules form a mineral mulch that protects the rest of the soil from the sun. Beneath the mulch the soil has poor structure and generally cracks into large, heavy clods. When the soil is dry, the cracks open up and the surface soil falls into them. When the soil is wet and swells, the cracks close and the subsoil material is pushed toward the surface. Thus, in the course of many years, the soil churns slowly over and over. Throughout the soil and particularly deep down where churning does not occur, there are aggregates and crystals of calcium carbonate, or calcite, and of calcium sulfate, or gypsum. These minerals are present because Vertisols occur in a dry or nearly dry climate and there is little leaching.

Although the soils are black or dark gray in color, they contain less organic matter than red soils do. The organic matter associated with montmorillonite may be naturally darker colored than that associated with the minerals in red soils. However, Raymundo [6] has found that the clay, silt, and sand fractions of these soils are gray in color, even when the organic matter is removed completely.

Three suborders of Vertisols occur in Hawaii: Torrerts, Uderts, and Usterts. Torrerts have cracks that remain open throughout the year in most years or are closed for less than 60 consecutive days at a period when the soil temperature at a depth of 50 centimeters (20 inches) is continuously more than 8° C. (46° F.). The prefix *Torr*, derived from the Latin word for *torrid*, indicates that the soils are usually dry. Uderts have cracks that open and close more than once each year but stay open for less than 90 cumulative days in most years. The prefix *Ud* indicates that the soils are in a humid climate. Usterts have cracks that open and close more than once each year and stay open for more than 90 cumulative days during the year in most years, but are closed for at least 60 consecutive days at a time when the soil temperature at a depth of 50 centimeters (20 inches) is continuously above 8° C. (46° F.). The prefix *Ust*, derived from the Latin word meaning *burnt*, indicates that summers are hot and dry. The suffix *ert* indicates the name of the order Vertisols.

Torrerts

Kapuhikani soils belong in the suborder Torrerts. They have deep, wide cracks that remain open throughout the year. They receive 10 to 15 inches of rainfall annually. The vegetation is sparse, and much of the surface is bare. A horizon high in content of calcium carbonate occurs at a depth of about 20 inches. Because of the dark-brown color in the surface layer, Kapuhikani soils are classified as Mollic Torrerts. They are dominated by montmorillonite clay minerals and have a mean annual soil temperature of 75° F. They are classified in the very-fine,

[6] RAYMUNDO, M. THE PROPERTIES OF THE BLACK EARTH OF HAWAII. 1965. [Unpublished Ph.D. dissertation. Copy on file University of Hawaii]

montmorillonitic, isohyperthermic family of Mollic Torrerts.

Uderts

Kaena soils belong in the suborder Uderts. They are gently sloping to moderately steep and are on fans and steep colluvial slopes at an elevation of 50 to 150 feet. The mean annual rainfall is between 30 and 45 inches. The mean annual soil temperature is 74° F. Kaena soils are poorly drained. They are very sticky and very plastic and crack widely when dry. The cracks stay open for less than 90 days each year. Kaena soils have chromas of less than 1.5 when moist and are classified in the great group Pelluderts. They are Typic Pelluderts because of strongly mottled horizons. The prefix *Pell* is derived from a Greek word that indicates low chroma. Because of montmorillonite clay minerals and a mean annual soil temperature of 74°, Kaena soils are classified in the very-fine, montmorillonitic, isohyperthermic family of Typic Pelluderts.

Usterts

Usterts that have chromas of 1.5 or more when moist are in the Chromusterts great group. Waihuna, Honouliuli, Lualualei, Makalapa, Nonopahu, and Papaa soils are classified as Chromusterts.

Waihuna soils are nearly level or gently sloping to moderately sloping and are in basins and on alluvial fans. The elevation ranges from 400 to 2,000 feet. The annual rainfall is 20 to 35 inches. Waihuna soils are very sticky and very plastic. They are dominated by tabular halloysitic minerals and have a mean annual soil temperature of 69° F. They are classified in the very-fine, kaolinitic, isothermic family of Typic Chromusterts.

Honouliuli soils are nearly level to gently sloping and are on lowlands. They are very sticky and very plastic and are dominated by tabular halloysitic minerals. They have a mean annual soil temperature of 74° F. and 18 to 30 inches of annual rainfall. They are classified in the very-fine, kaolinitic, isohyperthermic family of Typic Chromusterts.

Lualualei and Makalapa soils are dominated by montmorillonitic minerals and have a mean annual soil temperature of more than 71.6° F. They are gently sloping and are on marine alluvium and associated colluvial fans on the leeward side of the islands. They are classified in the very-fine, montmorillonitic, isohyperthermic family of Typic Chromusterts.

Nonopahu soils are classified as Entic Chromusterts because they grade to Entisols. They have a color value of more than 3.5 when moist. Because they are dominated by tabular halloysitic minerals and have a mean annual soil temperature of about 74° F., Nonopahu soils are classified in the very-fine, kaolinitic, isohyperthermic family of Entic Chromusterts.

Papaa soils are classified as Udic Chromusterts because they contain more moisture than the Typic Chromusterts. They have cracks that remain open from 90 to 150 cumulative days during the year. They are dominated by montmorillonitic minerals and have a mean annual soil temperature of 73° F. They are classified in the very-fine, montmorillonitic, isohyperthermic family of Udic Chromusterts.

Usterts that when moist have a chroma of less than 1.5 throughout the uppermost 12 inches are in the Pellusterts great soil group. Kokokahi soils are classified as Pellusterts. They have color values of more than 3.5 when moist and have cracks that remain open for less than 150 cumulative days during the year. They are therefore classified as Udorthentic Pellusterts, that is, soils that are moist (Udic) and are younger than typical. Kokokahi soils are dominated by montmorillonitic minerals and have a mean annual soil temperature of 74° F. They are classified in the very-fine, montmorillonitic, isohyperthermic family of Udorthentic Pellusterts.

Inceptisols

Inceptisols have weakly developed, natural soil horizons. Many of these soils are young but not recent. They are commonly older than Entisols. For example, in a river valley where there is a flood plain and an older terrace a few feet above the flood plain, Entisols are on the flood plain and Inceptisols generally on the older terrace.

The name of the order is derived from the Latin *inceptum*, meaning *beginning*. Recently, the order has been extended to include nearly all of the generally moist soils that have been little affected by those soil-forming processes that produce marked horizons in the soil profile. Thus, the order includes nearly all soils developed in volcanic ash and many strongly weathered soils in tropical zones, including Hawaii, that have been developing for many thousands of years but do not have oxic, spodic, or argillic horizons.

Three suborders of Inceptisols occur in the State of Hawaii: Andepts, which developed in volcanic ash; Aquepts, which show signs of wetness; and Tropepts, which developed in tropical climates and well-drained areas from strongly weathered alluvium or material weathered from basic rocks.

Andepts

Andepts have a high content of allophane or volcanic ash, have bulk density of less than 0.85 grams per cubic centimeter, and lack characteristics associated with wetness. The prefix *And* is derived from Andosols, which is the name ordinarily applied to soils that developed in volcanic ash. The suffix *ept* indicates the name of the order Inceptisols. Andepts are divided into four great groups: Vitrandepts, Eutrandepts, Dystrandepts, and Hydrandepts. These groups correspond with significant differences in the soil properties that are associated with differences in rainfall, temperature, and age.

Uma and Alae soils developed under sparse vegetation in a semiarid climate. They are classified as Vitrandepts. The prefix *Vitr*, taken from the Latin word for *glass*, indicates that these soils are relatively unweathered volcanic ash and show little profile development. Because of low rainfall and sparse vegetation, they have high base saturation and a low organic-matter content.

Uma soils have an A horizon of black loamy coarse sand over black unweathered cinders. They have a mean annual soil temperature of 56° F. They are therefore classified in the cindery, isomesic family of Typic Vitrandepts.

Alae soils receive 12 to 20 inches of annual rainfall. This amount is not enough to leach the bases and, therefore, base saturation is greater than 50 percent. These

soils have a mollic epipedon and are classified as Mollic Vitrandepts. Because of a dark-brown A horizon and a mean annual soil temperature of 74° F., Alae soils are classified in the medial, isohyperthermic family of Mollic Vitrandepts.

Eutrandepts formed in volcanic ash in a semiarid climate. Because of the low rainfall, there has been little leaching and base saturation is greater than 50 percent. The prefix *Eutr* is taken from the Greek word for *fertile*. In comparison with the soils classified as Vitrandepts, the soils in this great group show the effects of higher rainfall and increased vegetation in their darker colored, thicker surface layer and higher organic-matter content. They also have a higher clay content and a higher cation exchange capacity than Vitrandepts. Their base saturation is somewhat lower but exceeds 50 percent throughout the soil.

Kula, Io, and Ulupalakua soils on the island of Maui are classified as Typic Eutrandepts. Kula soils have an A horizon of dark reddish-brown loam that has weak structure. They have moderate structure in the upper part of the B horizon and strong structure in the lower part. Because they have a mean annual soil temperature of 66° F., Kula soils are classified in the medial, isothermic family of Typic Eutrandepts.

Io soils have a very dark-brown A horizon and a dark-brown to dark reddish-brown B horizon that has weak and moderate structure. They are underlain by black unweathered cinders at a depth of 20 to 40 inches. Ulupalakua soils have an A horizon of very dark-brown silt loam and a B horizon of dark reddish-brown silt loam and clay loam. They are underlain by black unweathered cinders at a depth of 24 to 40 inches. Because Io and Ulupalakua soils are underlain by cinders and have a mean annual soil temperature of between 65° and 69° F., they are classified in the medial over cindery, isothermic family of Typic Eutrandepts.

The Kalaupapa soils on the island of Molokai are classified in the subgroup Lithic Eutrandepts, which indicates that they are Eutrandepts that are truncated by hard rock and are shallow or are intermittent between rock outcrops. They have a dark-brown, strong granular A horizon and a dark yellowish-brown B horizon that rests on hard pahoehoe lava at a depth of about 14 inches. They have a mean annual soil temperature of 74° F. and are classified in the medial, isohyperthermic family of Lithic Eutrandepts.

Koko, Oanapuka, and Puu Pa soils formed under less rainfall than the soils classified as Typic Eutrandepts. They have a layer of soft, powdery, secondary lime and therefore are classified in an Ustollic subgroup. The prefix *Ust*, from the Latin word meaning *burnt*, indicates that the soils developed in a dry climate and that there is not enough rainfall to leach away entirely the calcium carbonate from the profile. The suffix *oll* indicates that the soils are considered intergrades to the Mollisol order.

Koko soils have an A horizon of dark reddish-brown granular silt loam and a dark reddish-brown B horizon that has weak to moderate structure. They occur on the slopes of Diamond Head, Koko Head, and Koko Crater, in a semiarid climate.

Oanapuka soils have an A horizon of very dark-brown and very dark grayish-brown silt loam. The B horizon is silt loam, has prismatic structure, and is weakly smeary. These soils occur on Maui. Koko and Oanapuka soils are weakly weathered and still contain much volcanic ash. They have a mean annual soil temperature of 73° F. They are classified in the medial, isohyperthermic family of Ustollic Eutrandepts.

Puu Pa soils have a very dark-brown A horizon and a very friable, massive C horizon. Because of a layer of fragmental Aa lava and a mean annual soil temperature of 70° F., Puu Pa soils are classified in the medial over fragmental, isothermic family of Ustollic Eutrandepts.

Andepts that formed in a humid climate belong to the Dystrandepts great group. The prefix *Dystr* is taken from the Greek word meaning *infertile*. Therefore, Dystrandepts are Andepts that have low base saturation because of higher rainfall and consequent leaching. They receive more rainfall than Eutrandepts but less than Hydrandepts. Annual rainfall ranges from 40 to about 100 inches. The organic-matter content is high, but base saturation is less than 50 percent.

Kaipoioi, Laumaia, Paaiki, Pane, and Tantalus are well-drained soils that do not have thixotropic properties. They are classified as Typic Dystrandepts.

Kaipoioi soils have a black A horizon that has strong structure and a silt loam and silty clay loam B horizon. Laumaia soils have a very dark-brown A horizon that has moderate structure. The upper part of the B horizon is dark-brown silt loam. These soils are underlain by a weakly cemented sandy layer. Their mean annual soil temperature is between 53° and 56° F. They are classified in the medial, isomesic family of Typic Dystrandepts.

Paaiki and Pane soils occur at the lower elevations on the island of Maui. Paaiki soils have a dark reddish-brown, granular A horizon and a brown B horizon that is silty clay loam in the upper part and silty clay in the lower part. Pane soils have a dark reddish-brown A horizon that has strong granular structure and a dark reddish-brown loamy B horizon that is weakly smeary. Paaiki and Pane soils have a mean annual soil temperature of between 60° and 66° F. They are classified in the medial, isothermic family of Typic Dystrandepts.

Tantalus soils have a very dark-brown A horizon over a dark reddish-brown very fine sandy loam B horizon. They have weak structure, are very friable, and are weakly weathered. Because these soils are underlain by cinders and have a mean annual soil temperature of 70° F., they are classified in the medial over cindery, isothermic family of Typic Dystrandepts.

Olinda soils have an A horizon of dark reddish-brown loam and a B horizon of silty clay loam that is weakly smeary. They do not have an umbric epipedon and therefore are not typic. They are classified as Entic Dystrandepts. They have a mean annual soil temperature of 57° F. and are classified in the medial, isomesic family of Entic Dystrandepts.

Niulii soils are similar to the soils classified as Typic Dystrandepts, but they have thixotropic properties and an umbric epipedon. Thus, they are classified as Hydric Dystrandepts to show that they intergrade to Hydrandepts. Niulii soils receive an average of 80 to 100 inches of rainfall annually, and their mean annual soil temperature is about 70° F. They have an A horizon of dark-brown silty clay loam that has strong structure and a

B horizon of dark-brown silty clay loam that is thixotropic. Niulii soils are classified in the thixotropic, isothermic family of Hydric Dystrandepts.

Mahana, Naiwa, and Oli soils formed in a subhumid, warm climate. They are strongly weathered and have practically no reserves of bases. Base saturation is low. Because of strong weathering, the surface soil contains many oxides and the soils are similar to those in the order Oxisols. Thus, they are placed in an Oxic subgroup where the cation exchange capacity is below 20 milliequivalents per 100 grams of soil. The low cation exchange capacity is caused by the high oxide content in the soil. Also, because of the strong weathering, the subsoil contains no volcanic ash but contains, instead, amorphous secondary minerals developed from the ash.

Mahana soils developed in old, strongly weathered volcanic ash in a subhumid, warm climate. They are nearly level to steep and are on uplands. Their A horizon is firm, dusky-red silty clay loam that has strong structure. It is underlain by dark-red silt loam that has weak structure. The A horizon contains an accumulation of iron and titanium oxides, which appear as small, dark-colored, shiny specks, and therefore has a much higher bulk density than is usual for soils derived from volcanic ash. The mean annual soil temperature is 67° F.

Naiwa soils have a dusky-red A horizon that has high bulk density and a red and dark reddish-brown silt loam B horizon that has weak to moderate structure. The A horizon and the upper part of the B horizon are more than 35 percent total iron oxides and more than 10 percent titanium oxide. The mean annual soil temperature is 70° F.

Oli soils have a dark-brown A horizon over a dark-brown B horizon that has weak structure. They are gently sloping to steep and are on dissected uplands. They developed in volcanic ash over basic igneous rock.

Because of a medial control section and a mean annual soil temperature of between 67° and 70° F., Mahana, Naiwa, and Oli soils are classified in the medial, isothermic family of Oxic Dystrandepts.

Andepts containing clays that dehydrate irreversibly into gravel-size aggregates are classified in the great group Hydrandepts. The prefix *Hydr* is taken from the Greek word meaning *water*. Hydrandepts occur in the wettest areas occupied by Andepts. They receive 80 to more than 300 inches of rainfall annually. They are the most strongly weathered of all the soils derived from volcanic ash. The cation exchange capacity is high, but base saturation is low. The organic-matter content is high. The moisture held by the soil at 15 atmospheres of tension often exceeds 200 percent. Water intake and transmission through the soil are rapid.

Honomanu, Kailua, and Hana soils are classified as Typic Hydrandepts. Honomanu soils have a very dark grayish-brown O1 horizon, a very dark-brown and dark yellowish-brown A horizon, and a dark yellowish-brown and brown B horizon. These soils are strongly smeary and dehydrate irreversibly into fine gravel-size aggregates. Kailua soils have an A horizon of dark-brown silty clay and a B horizon of dark-brown and dark reddish-brown silty clay. They are weakly or moderately smeary and dehydrate irreversibly into fine gravel-size aggregates. Because of thixotropic properties and a mean annual soil temperature of between 62° and 70° F., Honomanu and Kailua soils are placed in the thixotropic, isothermic family of Typic Hydrandepts.

Hana soils are similar to Honomanu and Kailua soils but have a mean annual soil temperature of more than 71.6° F. They have a very dark-brown A horizon and a dark-brown B horizon that is moderately smeary and dehydrates irreversibly into gravel-size aggregates. Because of a mean annual soil temperature of 73° F., Hana soils are classified in the thixotropic, isohyperthermic family of Typic Hydrandepts.

Aquepts

Eight soil series are classified in the suborder Aquepts. The prefix *Aqu*, derived from the Latin word meaning *water*, indicates the effect of wetness in the formation of these soils. Aquepts are mottled in the subsoil. The mottling indicates that the water table rises into the subsoil and periodically causes waterlogging and loss of oxygen. Consequently, the iron, which accounts largely for the bright color in soils and is insoluble when air is present, becomes dissolved in water and either moves out of the soil in drainage water or changes to gray or olive in color.

Amalu, Hulua, and Olokui soils are classified in the great group Placaquepts. The prefix *Plac*, taken from the Greek word *plax*, indicates the presence of a thin pan. Therefore, Placaquepts are Aquepts that have a thin black to reddish, cemented pan, presumably cemented with iron, that is called a placic horizon. Hulua and Olokui soils are placed in the typic, or central, subgroup.

Hulua soils have an A1 horizon of black gravelly silty clay over an acid A2 horizon that is shallow over a strongly cemented ironstone sheet. Elevations range from 400 to 2,400 feet. The annual rainfall is 100 to 200 inches. The mean annual soil temperature is about 66° F. Hulua soils are placed in the fine, oxidic, acid, isothermic family of Typic Placaquepts.

Olokui soils have an O horizon about 4 inches thick, an acid A2g horizon of mottled silty clay loam, and an ironstone sheet at a depth of about 12 inches. They occur at elevations of 1,500 to 4,000 feet and receive 75 to 150 inches of rainfall annually. The mean annual soil temperature is 58° F. Olokui soils are placed in the fine, mixed, acid, isomesic family of Typic Placaquepts.

Amalu soils are classified as Histic Placaquepts because they have a histic epipedon. They have a black peat surface layer 5 to 15 inches thick, an acid, gray clay A2 horizon, and an ironstone sheet 8 to 15 inches below the base of the peaty surface layer. They occur at elevations of 2,000 to 5,500 feet. The annual rainfall is 75 to 400 inches. The mean annual soil temperature is about 58° F. Amalu soils are placed in the fine, mixed, acid, isomesic family of Histic Placaquepts.

Aquepts that have a difference of less than 9° F. between the mean summer and mean winter temperatures are placed in the great group Tropaquepts. The prefix *Trop* means *tropical*.

Hanalei soils have a dark-gray to dark grayish-brown A horizon and a mottled dark-gray or dark grayish-brown silty clay loam B horizon. The water table is above a depth of 26 inches most of the time. Because these soils have a fine silty texture in the control section, have mixed mineralogy, mostly kaolin and montmorillonite, are

nonacid in the control section, and have a mean annual temperature of 74° F., they are placed in the fine, mixed nonacid, isohyperthermic family of Typic Tropaquepts. Pearl Harbor soils differ from Hanalei soils in containing a large amount of montmorillonite clay. They are therefore classified in the fine, montmorillonitic, nonacid, isohyperthermic family of Typic Tropaquepts. Pearl Harbor soils also have a layer of muck and peat that occurs at too great a depth to be significant for purposes of classification.

Keaau soils have an A horizon of very dark grayish-brown clay and a mottled dark-brown B horizon. They are underlain by coral limestone. Because of the clayey A horizon, the montmorillonitic mineralogy, a nonacid control section, and a mean annual soil temperature of 73° F., Keaau soils are classified in the very-fine, montmorillonitic, nonacid, isohyperthermic family of Typic Tropaquepts.

Kalihi soils have a dark-brown, clayey A horizon and a mottled very dark gray, very sticky and very plastic B horizon. The pH ranges from 6.4 to 7 throughout the solum. The dominant clay mineral is tabular halloysite. Kalihi soils are nearly level and occur on bottom land at elevations of 50 to 100 feet. They were formerly classified as Gray Hydromorphic soils by Cline (*5*). Because of the clay texture, the tabular halloysitic mineralogy, a nonacid control section, and a mean annual soil temperature of 74° F., Kalihi soils are classified in the very-fine, kaolinitic, nonacid, isohyperthermic family of Typic Tropaquepts.

Koolau soils are similar to Typic Tropaquepts but have mottles of more than 2 chroma. This fact indicates that they are slightly better drained. They are therefore classified as Aeric Tropaquepts. They are gently sloping to steep and are on uplands at elevations ranging from 750 to 5,200 feet. The annual rainfall is 120 to 200 inches. Koolau soils have a mottled light brownish-gray, clayey A1 horizon and a mottled gray to pale-yellow B horizon that is very strongly acid. The mottling indicates poor aeration. The soil material is very porous and is easily penetrated by water. Because of the clay texture, the tabular halloysitic mineralogy, an acid subsoil, and a mean annual soil temperature of 64° F., Koolau soils are classified in the fine, kaolinitic, acid, isothermic family of Aeric Tropaquepts.

Tropepts

Tropepts are Inceptisols that have a difference of less than 9° F. between the mean summer and mean winter soil temperatures. They include soils in tropical areas that are strongly weathered and have been developing for thousands of years but do not have an oxic, spodic, or argillic horizon. Tropepts are subdivided into two great groups: Humitropepts and Ustropepts. The groupings are based on differences in rainfall and temperature and on the relative amounts of organic matter in a unit of volume of 1 meter (40 inches) square to a depth of 1 meter.

Makaalae, Makiki, Haliimaile, Hihimanu, Kolekole, Kunia, Pohakupu, and Kolokolo soils are classified in the great group Humitropepts because they have high mean annual rainfall or high humus content. The prefix *Hum*, derived from the Latin word *humus*, meaning *earth*, indicates the presence of a relatively large amount of organic matter. These soils occur on bottom lands, uplands, and alluvial fans at elevations that range from sea level to 12,000 feet. The mean annual rainfall ranges from 35 to 150 inches but is generally between 80 and 140 inches.

Hanamaulu and Lawai soils have higher mean annual rainfall than most other Tropepts. They are always moist. They have a base saturation of less than 50 percent and a mean annual soil temperature of more than 71.6° F. Hanamaulu soils have a cation exchange capacity of less than 20 milliequivalents per 100 grams of clay and are therefore classified in an Oxic subgroup. They have a very dark grayish-brown A horizon and moderate and strong structure in the B2 horizon. Because the control section is fine textured, Hanamaulu soils are classified in the fine, oxidic, isohyperthermic family of Oxid Humitropepts. The Lawai soils are similar to the Hanamaulu soils except that they have a very fine texture in the control section. Lawai soils are classified in the very-fine oxidic, isohyperthermic family of Oxic Humitropepts.

Makaalae soils have a very dark brown A horizon that has strong subangular blocky structure and a very dark grayish-brown silty clay C horizon that is 35 to 70 percent coarse fragments. These soils are 24 to 48 inches deep over fragmental Aa lava. They are dry in some horizons for more than 90 cumulative days in most years. They are therefore classified as Ustic Humitropepts. Makaalae soils have mixed mineralogy and a mean annual soil temperature of about 73° F. They are classified in the clayey-skeletal, mixed, isohyperthermic family of Ustic Humitropepts.

Makiki soils have a dry period similar to that of Makaalae soils, but are influenced by volcanic ash. They are classified as Andic Ustic Humitropepts. They occur in Manoa Valley and along the base of Punchbowl and Round Top. Their subsoil is dark-brown clay loam of moderate structure. It is underlain by volcanic ash and cinders. Because of the clay loam texture, the mixed clay minerals, and a mean annual soil temperature of 73° F., Makiki soils are classified in the fine, mixed, isohyperthermic family of Andic Ustic Humitropepts.

Haliimaile, Hihimanu, Kolekole, Kunia, and Pohakupu soils are classified as Ustoxic Humitropepts because they are as dry as the soils classified as Ustic Humitropepts and have a cation exchange capacity that is less than 24 milliequivalents per 100 grams of clay. Kolekole and Hihimanu soils occur on the uplands of the island of Oahu and on the very steep parts of the island of Kauai.

Kolekole soils have an A horizon of dark reddish-brown silty clay loam that has high bulk density over a subsoil that is similar in color and texture but has low bulk density. The subsoil is underlain by very compact older alluvium that is capped by a thin panlike layer that restricts root and water movement. Kolekole soils have oxidic mineralogy and a mean annual soil temperature of about 71° F. Hihimanu soils have an A horizon of dark-brown silty clay loam and a dark-brown to reddish-brown B horizon. They are similar to Kolekole soils. Both soils are classified in the fine, oxidic, isothermic family of Ustoxic Humitropepts.

Haliimaile and Kunia soils are also similar to Kolekole soils, but they have tabular kaolinitic mineralogy. The

A and B horizons are dark reddish-brown silty clay. The mean annual soil temperature is 71° F. Because of the silty clay texture and tabular kaolinitic mineralogy, these two soils are classified in the fine, kaolinitic, isothermic family of Ustoxic Humitropepts.

Pohakupu soils are similar to Kunia soils, but they have oxidic mineralogy. Therefore, they are classified in the fine, oxidic, isohyperthermic family of Ustoxic Humitropepts.

Kolokolo soils occur on bottom lands along small and large streams on the eastern and northern sides of the island of Kauai. They are associated with Fluvents and intergrade toward those soils. They have a very dark brown, subangular blocky A horizon and a stratified C horizon that has an irregularly decreasing organic-matter content. The mineralogy is mixed. The mean annual soil temperature is about 73° F. Kolokolo soils are classified in the fine, mixed, isohyperthermic family of Fluventic Humitropepts.

Pakala soils are classified in the great group Ustropepts. They have the least mean annual rainfall of the Tropepts. The prefix *Ust* is from the Latin word *ustus*, meaning *burnt*. It indicates a dry climate. These soils are dry for 90 cumulative days or more in most years; they receive 25 to 40 inches of rainfall. They are nearly level and occur on alluvial fans and flood plains. The A horizon is dark reddish-brown clay loam. The C horizon is stratified silty clay loam to silt loam and has an irregularly decreasing organic-matter content. Pakala soils have a mean annual soil temperature of 74° F. Their cation exchange capacity is less than 24 milliequivalents per 100 grams of clay, and they are high in oxides. They are placed in the fine, oxidic, isohyperthermic family of Fluventic Ustropepts.

Aridisols

Aridisols are primarily soils of dry places. They have an ochric epipedon and one or more additional diagnostic horizons. The order includes most soils formerly called Desert soils, Red Desert soils, Sierozems, Reddish Brown soils, and Solonchak soils (*15*). It also includes some of the Regosols and Lithosols of dry climates and some Brown soils and Solonetz soils.

The Aridisols that have no argillic or natric horizon but have a salic horizon and are saturated with water within 40 inches of the surface for 1 month or more are placed in the suborder Orthids. The suffix *id* indicates the order Aridisols.

Orthids

The only soil on the five islands in the Aridisol order and Orthid suborder is Kealia silt loam. Within the suborder, the Kealia soil is placed in the great group Salorthids. The prefix *Sal*, derived from the Latin base for *salt*, indicates that the soil is saline. Within this great group, the Kealia soil is placed in the typic, or central, subgroup.

The Kealia soil has a dark reddish-brown Asa horizon over a stratified, dark reddish-brown and black Csa horizon. The stratified material was laid down by streams along the coastal flats. This soil has a fluctuating salt water table at a depth of 12 to 40 inches, and as a result, is saline and poorly drained. The annual rainfall is 10 to 25 inches. The mean annual soil temperature is 75° F. The Kealia soil is classified in the coarse-loamy, mixed, isohyperthermic family of Typic Salorthids.

Mollisols

Mollisols have a mollic epipedon that has high base saturation and generally has moderate to strong granular structure. The order includes most soils formerly classified as Prairie soils, Chernozems, and Chestnut soils (*15*), and most soils that have a dark-colored surface layer and developed over limestone. Mollisols generally develop under grass vegetation where the grass is dense enough to form a sod. A few developed under sedges and water-tolerant plants and under hardwood forest.

Two suborders of Mollisols occur in the State of Hawaii: Aquolls and Ustolls. Aquolls show signs of wetness and, unless drained, are saturated with water for 1 month or more during most years. Ustolls are dry soils that have high base saturation. The prefix *Ust*, derived from the Latin word *ustus*, meaning *burnt*, indicates that the soils developed in an area that has dry, hot summers. The suffix *oll* indicates the name of the order Mollisols.

Aquolls

Nohili and Kaloko soils are classified in the suborder Aquolls because they are saturated with water at some period during the year. Nohili soils have a clayey A horizon; a slightly calcareous, clayey B2 horizon, or mollic epipedon, more than 24 inches thick; and a strongly calcareous, massive C horizon. The rainfall is 20 to 40 inches annually. The mean annual soil temperature is about 75° F. Nohili soils do not have a duripan, a natric horizon, a calcic horizon, or an argillic horizon, and are therefore classified as Haplaquolls. *Hapla* is a prefix meaning *simple*. Nohili soils are further classified in the fine, montmorillonitic (calcareous), isohyperthermic family of Cumulic Haplaquolls.

Kaloko soils are poorly drained and have mottles in the mollic epipedon. They occur at elevations that range from 0 to 20 feet. The annual rainfall is 20 to 25 inches, and the mean annual soil temperature is about 73° F. These soils have clay over marl at a depth of 12 to 20 inches. They are classified in the fine, carbonatic, isohyperthermic family of Typic Haplaquolls.

Twenty-one soils have been classified in the suborder Ustolls. This suborder includes soils that are dry for 90 cumulative days but not continuously dry for 60 consecutive days. They are further classified in the great group Haplustolls (*Hapla* means *simple*) because they do not have an argillic horizon, a calcic horizon, a duripan, or a natric horizon.

Some soils previously classified as Low-Humic Latosols by Cline (*5*) are now classified in the suborder Ustolls. The prefix *Ust* indicates that the soils are often dry and consequently have high base saturation.

Haleiwa, Iao, Paia, and Waialua soils are classified as Typic Haplustolls. They are nearly level to moderately sloping and occur on alluvial fans and uplands at elevations that range from sea level to 1,000 feet. The mean annual rainfall is 25 to 60 inches.

Haleiwa soils have a dark-brown A horizon and a weak subangular blocky B horizon that is silty clay in texture. Mineralogy is mixed. The mean annual soil temperature is about 73° F. Haleiwa soils are classified

in the fine, mixed, isohyperthermic family of Typic Haplustolls.

Iao soils have a dark-brown, massive A horizon and a very dark brown and dark-brown, subangular blocky B horizon. Both horizons are clay in texture. Paia soils have a dark reddish-brown, granular and subangular blocky A horizon and a dark reddish-brown clay B horizon. Both soils have tabular halloysitic mineralogy and a mean annual soil temperature of 73° or 74° F. Both are classified in the fine, kaolinitic, isohyperthermic family of Typic Haplustolls.

Waialua soils have a dark reddish-brown, subangular blocky A horizon and a subangular blocky B horizon. Mineralogy is dominated by tabular halloysite. The mean annual soil temperature is about 73° F. These soils are classified in the very-fine, kaolinitic, isohyperthermic family of Typic Haplustolls.

Aridic Haplustolls are Haplustolls that intergrade to Aridisols, that is, soils that are usually dry. The mean annual rainfall is generally between 10 and 25 inches but can be as high as 35 inches. Ewa, Hoolehua, and Waiakoa soils have a mean annual soil temperature of more than 71.6° F. Their mineralogy is dominated by tabular halloysite. Ewa soils have a dark reddish-brown A horizon and a dark reddish-brown to dark-red B horizon. Hoolehua soils have a dark reddish-brown A horizon and a dark reddish-brown B horizon. Both horizons are silty clay in texture. Waiakoa soils have a dark reddish-brown A horizon and are 20 to 40 inches deep over bedrock. All three soils are classified in the fine, kaolinitic, isohyperthermic family of Aridic Haplustolls. Koele soils differ mainly in having a mean annual soil temperature of about 69° F. They are classified in the fine, kaolinitic, isothermic family of Aridic Haplustolls.

Kamaole soils have a dark-brown and dark reddish-brown A horizon and a dark reddish-brown B horizon over fragmental Aa lava at a depth of 16 to 24 inches. They have a mean annual soil temperature of 69° F. and are classified in the clayey over fragmental, kaolinitic, isothermic family of Aridic Haplustolls. Keawakapu soils differ from Kamaole soils mainly in having an annual soil temperature of more than 71.6° F. and are classified in the clayey over fragmental, kaolinitic, isohyperthermic family of Aridic Haplustolls.

Makena soils have a very dark brown and very dark grayish-brown, mildly alkaline A horizon. The lower part of the B horizon and the C horizon are dark yellowish brown and contain a considerable amount of volcanic ash. Some lime has accumulated in the Cca horizon as a result of low rainfall and limited leaching. Makena soils have a mean annual soil temperature of about 75° F. and receive 10 to 20 inches of annual rainfall. They are classified in the coarse-loamy, ashy, isohyperthermic family of Aridic Haplustolls.

Wainee soils have dark reddish-brown A and B horizons. The control section is gravelly, cobbly, and stony silty clay. The mineralogy is dominated by tabular halloysite. The mean annual soil temperature is about 75° F. Wainee soils are classified in the clayey-skeletal, kaolinitic, isohyperthermic family of Aridic Haplustolls.

Kawaihapai, Kekaha, and Pulehu soils are classified as Cumulic Haplustolls because they have a mollic epipedon more than 20 inches thick and an irregularly decreasing organic-matter content. Kawaihapai soils have a dark-brown A horizon 22 inches thick over an unconformable dark-brown, massive IIC horizon. The mean annual soil temperature is about 74° F. The mineralogy is mixed. Kawaihapai soils are classified in the fine, mixed, isohyperthermic family of Cumulic Haplustolls.

Kekaha soils have a dark reddish-brown, granular and subangular blocky A horizon 21 inches thick and a dark reddish-brown B horizon that is silty clay and clay in texture. The mean annual soil temperature is about 74° F. The mineralogy is mixed. Kekaha soils are classified in the very-fine, mixed, isohyperthermic family of Cumulic Haplustolls.

Pulehu soils have a dark-brown A horizon that is 21 inches thick and is clay loam in texture, and a stratified C horizon. The mineralogy is mixed. The mean annual soil temperature is about 74° F. Pulehu soils are classified in the fine-loamy, mixed, isohyperthermic family of Cumulic Haplustolls.

Mokuleia soils are classified as Entic Haplustolls because they have a calcareous mollic epipedon and do not have a cambic horizon. Mokuleia soils occur at elevations that range from near sea level to about 100 feet and receive 15 to 40 inches of rainfall annually. They have a dark-colored A horizon and a loamy sand or sand C horizon. The sand fraction is coral sand. Mokuleia soils are classified in the sandy, carbonatic, isohyperthermic family of Entic Haplustolls.

Waikomo and Mamala soils are classified as Lithic Haplustolls because they are less than 20 inches deep over bedrock. Waikomo soils have a very dark grayish-brown silty clay A horizon. The B horizon is reddish-brown silty clay loam. These soils overlie pahoehoe lava. They have mixed mineralogy and a mean annual soil temperature of 74° F. They are classified in the clayey, mixed, isohyperthermic family of Lithic Haplustolls.

Mamala soils have coral limestone at a depth of 8 to 20 inches. They are nearly level to gently sloping and occur on coastal plains. The elevation ranges from sea level to 100 feet. The annual rainfall is 18 to 25 inches, and the mean annual soil temperature is about 74° F. Mamala soils are classified in the clayey, kaolinitic isohyperthermic family of Lithic Haplustolls.

Kaupo soils are classified as Pachic Haplustolls (*Pachic* means *thick*) because they have a mollic epipedon more than 20 inches thick. The mollic epipedon is very dark brown and very dark grayish brown. The organic-matter content decreases gradually to the fragmental Aa lava, which is at a depth of 20 to 40 inches. The B horizon is silty clay loam in texture and is more than 40 percent gravel and cobblestones. Kaupo soils have mixed mineralogy and a mean annual soil temperature of about 74° F. They are classified in the fine-silty over fragmental, mixed, isohyperthermic family of Pachic Haplustolls.

Haplustolls that intergrade to Torrerts, that is, Vertisols that are usually dry, are classified as Torrertic Haplustolls. These soils are very sticky and very plastic clays that crack when dry and remain open throughout the year in most years. Pamoa and Waipahu soils are dominated by tabular halloysite mineralogy and have a mean annual soil temperature greater than 71.6° F. Pamoa soils have a solum of dark reddish-brown silty clay to clay. They have a thin, strong, granular surface

mulch and deep wide cracks when dry. Waipahu soils have a dark grayish-brown A horizon and a dark-brown B horizon. They have prominent, very fine nodules of manganese oxide throughout. Both soils are classified in the very-fine, kaolinitic, isohyperthermic family of Torrertic Haplustolls.

Waiawa soils are classified as Lithic Vertic Haplustolls because they are less than 20 inches deep over bedrock and are very sticky and very plastic clays that crack when dry. Waiawa soils have a dark reddish-brown, clayey solum. They have montmorillonitic mineralogy and a mean annual soil temperature of 74° F. They are placed in the clayey, montmorillonitic, isohyperthermic family of Lithic Vertic Haplustolls.

Spodosols

Spodosols have a spodic horizon in which active amorphous material consisting of organic matter and, in places, aluminum have accumulated. Spodic horizons occur only in humid environments. They form in soils that have a shallow, fluctuating, ground-water level, but ordinarily do not form in soils that are permanently saturated.

Waialeale soils belong in the suborder Aquods. The prefix *Aqu*, derived from the Latin word for *water*, indicates that the soil has characteristics associated with wetness. The suffix *od* indicates the order Spodosols.

Aquods

Within the suborder Aquods, Waialeale soils are placed in the great group Tropaquods. The prefix *Trop* is taken from the Greek word meaning *tropical*. Tropaquods are Aquods that occur in a tropical climate that has less than 9° F. difference between the mean summer and mean winter temperatures.

Waialeale soils are classified as Histic Lithic Tropaquods because they have a histic epipedon and are 9 to 22 inches deep over weathered rock. These soils have a thin O1 horizon over an albic horizon. The albic horizon overlies a strong-brown spodic horizon. Elevations range from 3,500 to 4,800 feet. The annual rainfall ranges from 100 to 450 inches. The mean annual soil temperature is about 57° F. Waialeale soils are placed in the fine, oxidic, isomesic family of Histic Lithic Tropaquods.

Alfisols

Alfisols are generally moist and contain an argillic horizon, that is, a subsoil horizon in which clay has accumulated. This horizon of clay accumulation forms because clay particles are washed from upper horizons and deposited in lower ones. Alfisols characteristically have a relatively low base saturation and a slightly to medium acid reaction in the surface layer and a relatively high base saturation and slightly acid to neutral reaction in the argillic horizon.

Alfisols are defined as soils that have an argillic horizon in which base saturation is more than 35 percent, and which, in moist climates, generally rests on calcareous parent material. Alfisols develop either in calcareous parent material in a humid climate or in strongly weathered parent material in a subhumid climate where the rain does not penetrate deep enough into the soil to leach out the exchangeable cations. In some subhumid areas, the effectiveness of the rain in leaching the soil is reduced by salt spray.

Only the suborder Ustalfs is represented on the islands.

Ustalfs

Kanepuu and Kemoo soils are placed in the suborder Ustalfs because some of their horizons are dry for more than 90 cumulative days in most years, but are continuously moist in some part for 90 or more consecutive days.

Kanepuu soils are classified as Paleustalfs because they have an argillic horizon in which the clay distribution is such that the percentage of clay does not decrease from its maximum by as much as 20 percent of that maximum to a depth of 60 inches. Also, throughout the major part of the horizon, hues are 7.5YR or redder and values are less than 4 moist and less than 5 dry. Kanepuu soils occur at elevations of 1,500 to 2,000 feet and receive 20 to 25 inches of rainfall annually. The mean annual soil temperature is about 70° F. Kanepuu soils have a dark reddish-brown, slightly acid to neutral solum. Their B horizon is silty clay that has strong subangular blocky structure. Within the great group Paleustalfs, Kanepuu soils are placed in the Oxic subgroup because they have a cation exchange capacity of less than 24 milliequivalents per 100 grams of clay. Finally, this soil is classified in the fine, oxidic, isothermic family of Oxic Paleustalfs.

Kemoo soils are placed in the great group Rhodustalfs because they have an argillic horizon that has hues redder than 5YR and color values less than 4 moist and no more than 5 dry. The A horizon is very dusky red to dark reddish brown. The B horizon is dark reddish-brown to dusky-red silty clay. The mean annual soil temperature is 69° F. Kemoo soils are further classified as Oxic Rhodustalfs because they have a cation exchange capacity of less than 24 milliequivalents per 100 grams of clay, or because the cation retention from ammonium chloride is less than 12 milliequivalents per 100 grams of clay. Finally, these soils are placed in the fine, oxidic, isothermic family of Oxic Rhodustalfs.

Ultisols

Ultisols, like Alfisols, have an argillic horizon in the subsoil. They formed either in a wetter climate than Alfisols or in more strongly weathered parent material. Leaching has removed most of the exchangeable cations from the soil profile. As a result, the soils are strongly to extremely acid throughout. In contrast with Alfisols, Ultisols have less than 35 percent base saturation in the lower part of the argillic horizon.

The order includes most of the soils that were classified as Humic Latosols and Humic Ferruginous Latosols by Cline (*5*).

Most of the Ultisols in Hawaii are classified in the suborder Humults, which are those Ultisols that have 1.5 percent or more organic matter in the upper part of the argillic horizon. Humults are further classified in the great group Tropohumults because of their tropical climate. The difference between the mean summer and mean winter temperatures is less than 9° F.

Humults

Thirteen soil series are classified in the subgroup Humoxic Tropohumults. These Tropohumults have a

cation exchange capacity of less than 24 milliequivalents per 100 grams of clay and a mean annual soil temperature below 71.6° F.

Haiku soils have a dark-brown A horizon that has high bulk density and a B horizon that contains gibbsite nodules or sheets. They are gently sloping and are on uplands at elevations that range from near sea level to 1,200 feet. The average annual rainfall is between 50 and 80 inches. The mean annual soil temperature is 70° F. Haiku soils are clay and silty clay in texture and are high in iron oxides. Pauwela soils are clayey and have high bulk density in the A horizon. They have a high iron oxide content, a well-developed argillic horizon, and a mean annual soil temperature of 70° F. Haiku and Pauwela soils are classified in the clayey, ferritic, isothermic family of Humoxic Tropohumults.

Kokee soils have an A horizon of dark-brown silty clay loam over a B horizon of strong-brown and dark-brown heavy silty clay loam and silty clay. They occur at elevations of 3,400 to 4,200 feet. The average annual rainfall is 60 to 70 inches. The mean annual soil temperature is about 59° F. These soils are classified in the clayey, oxidic, isomesic family of Humoxic Tropohumults.

Honolua, Kalapa, Kaneohe, Leilehua, Lolekaa, Makawao, Olelo, Paaloa, Paumalu, and Waikane soils occur at elevations that range from near sea level to 3,500 feet. They have an average annual rainfall of between 40 and 100 inches. The mean annual soil temperature is between 63° and 71° F. All of these soils are silty clay or clay in texture in the upper part of the B horizon and are high in iron oxides. They are classified in the clayey, oxidic, isothermic family of Humoxic Tropohumults.

Halawa, Hamakuapoko, Manana, Alaeloa, and Ioleau soils are classified in the subgroup Orthoxic Tropohumults. This subgroup indicates that the soils are Tropohumults that have a cation exchange capacity below 24 milliequivalents per 100 grams of clay and are either dry in part of the profile for 60 consecutive days or more, or the mean annual soil temperature is 72° F. or higher.

Halawa soils occur at elevations that range from 500 to 3,000 feet. The annual rainfall is 30 to 60 inches. The mean annual soil temperature is 69° F. These soils have a dark reddish-brown surface layer that has high bulk density. The upper part of this layer has strong structure, but the lower part is structureless. The subsoil is reddish brown and dark reddish brown and has strong and moderate structure. Halawa soils are strongly acid to very strongly acid and have a strongly developed argillic horizon.

Hamakuapoko soils developed in residuum weathered from basic igneous rock. They occur at elevations of 500 to 1,200 feet. The annual rainfall is 40 to 60 inches. The mean annual soil temperature is 71° F. Hamakuapoko soils have an A horizon of dark-brown silty clay that has high bulk density. The B horizon has nearly continuous clay films on ped faces.

Manana soils developed in old alluvium and residuum at elevations of 500 to 1,200 feet. The annual rainfall is 40 to 60 inches. The mean annual soil temperature is about 70° F. These soils have a dark reddish-brown A horizon that has moderate structure and high bulk density over a dusky-red and dark reddish-gray, firm B horizon that has strong structure. A very compact layer occurs at a depth of 15 to 50 inches. Manana soils are strongly acid throughout and have a strongly developed argillic horizon.

Halawa, Hamakuapoko, and Manana soils are silty clay in texture and are high in iron oxides. Their mean annual soil temperature is between 69° and 71° F. They are, therefore, classified in the clayey, oxidic, isothermic family of Orthoxic Tropohumults.

Alaeloa soils developed in material weathered from basic igneous rock. They are at elevations of 100 to 1,750 feet. The average annual rainfall is 35 to 60 inches. The mean annual soil temperature is about 72° F. The A horizon is dark reddish brown and has strong structure. The argillic horizon has strong structure and continuous, thick clay films in the lower part.

Ioleau soils also developed in residuum from basic igneous rock. They occur at elevations of 100 to 750 feet. The average annual rainfall is 40 to 70 inches. The mean annual soil temperature is 72° F. These soils have a dark-brown A horizon over a compact, clayey B horizon.

Alaeloa and Ioleau soils are both silty clay to silty clay loam in texture, are high in iron oxides, and have a mean annual soil temperature of more than 71.6° F. They are classified in the clayey, oxide, isohyperthermic family of Orthoxic Tropohumults.

Ustults

Two soils are classified in the suborder Ustults. These are Ultisols that are never saturated and are dry for 90 cumulative days but not continuously dry for 60 consecutive days. They are further classified in the great group Rhodustults because they have a epipedon that when moist has a color value of less than 4 and an argillic horizon that when dry has a value of less than 5 in all subhorizons.

Kalae and Puu Opae soils are classified in the subgroup Typic Rhodustults. Kalae soils developed in residuum and old alluvium influenced by volcanic ash. They occur at elevations that range from 750 to 2,200 feet. The annual rainfall is 30 to 50 inches. The mean annual soil temperature is 70° F. The A horizon is dark reddish brown and has moderately high bulk density. The B horizon is red and dark-red silty clay that has strong subangular blocky structure and continuous clay films.

Puu Opae soils occur in climatic and physiographic positions similar to those of the Kalae soils. They have a dusky-red A horizon and a reddish-brown silty clay argillic horizon.

Kalae and Puu Opae soils are silty clay in texture, are high in iron oxides, and have a mean annual temperature of about 70° F. They are classified in the clayey, oxidic, isothermic family of Typic Rhodustults.

Oxisols

Oxisols are generally reddish in color and have a rather featureless profile similar to that of the strongly weathered, tropical Mollisols and Inceptisols, which they closely resemble. In contrast with the Mollisols and Inceptisols they have a low cation exchange capacity and consist almost entirely of kaolin minerals and crystalline oxides of silica, iron, aluminum, and titanium, all of

which are resistant to weathering. Oxisols characteristically occur in tropical regions where weathering is intense.

The order includes many of the Low-Humic Latosols and the Humic Ferruginous Latosols as classified by Cline (*5*).

Most of the Oxisols in Hawaii developed on low uplands in a semiarid to humid climate. They occur on the older islands of Kauai, Oahu, Maui, Molokai, and Lanai where factors are favorable for nearly complete weathering of primary minerals.

Four suborders of Oxisols occur in Hawaii: Humox, Orthox, Ustox, and Torrox. Humox soils have a relatively high organic-matter content, a mean annual soil temperature of less than 72° F., and less than 35 percent base saturation in the Oxic horizon. The prefix *Hum* indicates that the soils have a high organic-matter content. Orthox soils have a mean annual soil temperature of more than 72° F. or lack enough organic carbon to qualify as Humox. They are not dry for as long as 60 consecutive days in all parts of the moisture control section. The prefix *Orth* is derived from the Greek word meaning *true* or *common*. Ustox soils are dry in some or all parts of the moisture control section for more than 90 cumulative days in most years, but are continuously moist in some part for 90 consecutive days. The prefix *Ust*, derived from the Latin word meaning *burnt*, indicates a dry climate. Torrox soils are dry more than half the time in most years. The prefix *Torr*, derived from the Latin word meaning *hot* and *dry*, indicates a hot, dry climate. The suffix *ox* is derived from the order Oxisols.

Humox

Makapili, Pooku, Kahanui, Halii, and Kapaa soils are classified in the suborder Humox. They occur in areas where annual rainfall ranges from 60 to 200 inches. The high rainfall keeps the soils moist and accounts for the abundant vegetative cover, the high organic-matter content, and the strong structure in the A horizon. The base saturation is less than 35 percent. The bases are leached out of the soil and replaced by hydrogen cations. As a result, fertility is low.

Makapili and Pooku soils are placed in the great group Acrohumox. The prefix *Acr*, derived from the Greek word *akros*, indicates extreme weathering. Makapili and Pooku soils are classified in the typic subgroup of Acrohumox.

Makapili soils have a brown A horizon that has strong structure and a very strongly acid B2 horizon. Pooku soils have an A horizon of dark-brown silty clay that contains ironstone-gibbsite concretions. The B horizon is dark reddish brown. Because of clay loam or silty clay texture in the control section, a high iron oxide content, and a mean annual soil temperature of 71° F., Makapili and Pooku soils are classified in the clayey, ferritic, isothermic family of Typic Acrohumox.

Kahanui soils occur on uplands on the islands of Molokai and Lanai. They belong to the subgroup Petroferric Acrohumox because they have a petroferric (ironstone) contact within 50 inches of the surface. Kahanui soils have an A horizon of dark-brown, gravelly silty clay and a B horizon of dark yellowish-brown silty clay. The A horizon is gravelly because it contains many ironstone fragments. A discontinuous ironstone sheet occurs in the B horizon. Because of clay texture in the control section, a high iron oxide content, and a mean annual soil temperature of 62° F., Kahanui soils are classified in the clayey, ferritic, isothermic family of Petroferric Acrohumox.

Halii and Kapaa soils are classified in the great group Gibbsihumox because they have cemented sheets or 20 percent or more gravel-size aggregates that are 30 percent or more gibbsite. They are in the typic subgroup.

Halii soils receive 100 to 200 inches of rainfall annually. Vegetation is abundant. The A horizon is very dark grayish-brown gravelly silty clay loam, and the B horizon dark reddish-brown silty clay. The gravelly material consists of hardened, smooth ironstone pebbles. Because of silty clay texture in the control section, a high iron oxide content, and a mean annual soil temperature of about 71° F., Halii soils are classified in the clayey, ferritic, isothermic family of Typic Gibbsihumox.

Kapaa soils receive 80 to 120 inches of rainfall. They have weak structure throughout, lack smooth ironstone pebbles, are less than 40 percent free iron oxides in the control section, and have a mean annual soil temperature of 71° F. They are classified in the clayey, gibbsitic, isothermic family of Typic Gibbsihumox.

Orthox

Kunuweia and Puhi soils belong in the suborder Orthox. Puhi soils have a mean annual soil temperature of 72° F. or more and receive 40 to 150 inches of rainfall annually. Kunuweia soils have less than 20 kilograms of organic carbon per square meter within the upper meter (40 inches). Neither soil is dry below the surface 7 inches for 60 consecutive days or more in most years, nor is either saturated. Neither has plinthite that forms a continuous phase within 12 inches of the surface if saturated at this depth.

Soils in the Orthox suborder that have a cation retention capacity of 1 milliequivalent or less and contain no gravel-size aggregates that are 30 percent or more gibbsite are placed in the great group Acrorthoxs. Soils in this great group are extremely weathered. Kunuweia soils have plinthite and, therefore, are classified as Plinthic Acrorthox. They have a dark-brown, very gravelly A horizon. The B horizon contains discontinuous bands of plinthite. Because of clay loam texture in the control section, ferritic mineralogy, and a mean annual soil temperature of 58° F., Kunuweia soils are classified in the clayey, ferritic, isomesic family of Plinthic Acrorthox.

Puhi soils belong in the great group Umbriorthox. They are wetter than Lihue soils but drier than Kapaa soils. They are 1.8 percent humus in all horizons to a depth of 30 inches or more, have base saturation of less than 35 percent, have no sheets of gibbsite, and have a cation retention of more than 1 milliequivalent per 100 grams of clay. They are classified in the great group of Umbriorthox, and in the typic subgroup. Puhi soils have a silty clay loam control section, have more than 10 percent silicon dioxide in the whole soil, have no nodules or sheets that are more than 30 percent gibbsite, and have a mean annual temperature of 73° F. They are, therefore, classified in the clayey, oxidic, isohyperthermic family of Typic Umbriorthox.

Torrox

Oxisols that are dry for more than half the time (cumulative) in most years and have a mean annual soil temperature of 72° F. or more are placed in the suborder Torrox. The prefix *Torr* indicates that these soils are usually dry. Unless irrigated, they are too dry to cultivate. They are probably relicts preserved from some former pluvial period. The nine soil series in the suborder Torrox are so similar that no subdivisions seem justified at the great group or subgroup level. They are dominantly red in color, contain little organic matter, and have relatively high base saturation. They are classified as Typic Torrox.

Holomua, Keahua, Lahaina, Makaweli, Molokai, Niu, Uwala, Waikapu, and Wahikuli soils formed in residuum and alluvium derived from basic igneous rock. They are gently sloping to very steep and occur on uplands and alluvial fans where the rainfall is 15 to 40 inches annually.

Holomua soils have a dark reddish-brown, granular and subangular blocky A horizon and a dark reddish-brown silty clay loam B horizon.

Keahua soils have a dark reddish-brown, weak granular A horizon and a silty clay loam B horizon that has nearly continuous pressure cutans in the lower part.

Lahaina soils have an A horizon of dark reddish-brown silty clay, a dusky-red and dark reddish-brown B horizon, and black concretions throughout the solum that effervesce with hydrogen peroxide.

Makaweli soils have a dusky-red A horizon that has weak structure and a dusky-red B horizon that has weak prismatic structure.

Molokai soils have a dark reddish-brown A horizon that has weak granular and subangular blocky structure and is silty clay loam in texture. The B horizon is dark reddish brown and has weak prismatic structure in the upper part. These soils have black concretions that effervesce with hydrogen peroxide.

Niu soils have a dark reddish-brown A horizon that is silty clay loam in texture and a B horizon that has nearly continuous coatings on ped faces.

Waikapu soils have a dark reddish-brown, granular and subangular blocky A horizon that is silty clay loam in texture. The B horizon has subangular blocky structure and contains common fine black concretions.

Wahikuli soils are gently to moderately sloping and occur on uplands on the island of Maui. They have an A horizon that is silty clay in texture and a B horizon that has patchy pressure cutans on ped faces.

Uwala soils have a dark reddish-brown A horizon that has subangular blocky structure and a dark reddish-brown B horizon that has pressure cutans in the lower part.

All of these soils are clayey in the control section and have mineralogy dominated by tabular halloysite. All but Uwala soils have a mean annual soil temperature of more than 72° F. Therefore, all but Uwala soils are classified in the clayey, kaolinitic, isohyperthermic family of Typic Torrox. Uwala soils have a mean annual soil temperature of about 70° F. They are classified in the clayey, kaolinitic, isothermic family of Typic Torrox.

Ustox

Oxisols that are dry for 60 consecutive days or more in most years and have a mean annual soil temperature of 59° F. or more are placed in the suborder Ustox. The prefix *Ust* indicates a dry climate. Six soil series in this suborder are represented on the islands. They are further classified in the great groups Eutrustox and Haplustox because they have a cation retention capacity of more than 1 milliequivalent per 100 grams of clay. Soils in the Eutrustox great group have base saturation of 50 percent or more in the oxic horizon. Those in the Haplustox great group have base saturation of less than 50 percent in the oxic horizon. The prefix *Eutr*, derived from the Greek word *eutrophic*, indicates high base saturation. The prefix *Hapl*, derived from the Greek word *haplous*, indicates minimum horizon.

Because these Eutrustox and Haplustox soils either have no structure in the oxic horizon, or have an oxic horizon that extends to a depth of 50 inches or more, they are classified as Tropeptic Eutrustox and Tropeptic Haplustox respectively.

Koloa, Lihue, and Wahiawa soils are classified as Tropeptic Eutrustox. Koloa and Lihue soils have a mean annual soil temperature of 59° F. or more and receive 40 to 60 inches of rainfall annually.

Koloa soils have a dark reddish-brown A horizon that contains stones and a dark reddish-brown and dark-red B horizon. They are 20 to 40 inches deep over pahoehoe bedrock. Because they have silty clay texture in the control section, tabular halloysitic mineralogy, a mean annual soil temperature of 74° F., and are 20 to 40 inches deep, Koloa soils are classified in the clayey, kaolinitic, isohyperthermic, shallow family of Tropeptic Eutrustox.

Lihue soils occur on low uplands on the island of Kauai. They are similar to Koloa soils but are very deep. They have an A horizon of dusky-red silty clay and a dark reddish-brown to dark-red, very compact B horizon. Because they have clay texture in the control section, tabular halloysitic mineraligy, and a mean annual soil temperature of 73° F., Lihue soils are classified in the clayey, kaolinitic, isohyperthermic family of Tropeptic Eutrustox.

Wahiawa soils occur on broad, smooth uplands on the Wahiawa Plateau on the island of Oahu. They have an A horizon of very dusky red silty clay and a compact B horizon that has moderate or strong structure. Manganese compounds are common throughout the soil. Because of silty clay texture in the control section that is dominated by halloysite, and a mean annual soil temperature of 71° F., Wahiawa soils are classified in the clayey, kaolinitic, isothermic family of Tropeptic Eutrustox.

Helemano, Kahana, and Wailuku soils have base saturation of less than 50 percent in some part of the oxic horizon. They receive 20 to 60 inches of rainfall.

Helemano soils formed in colluvium and alluvium derived from basic igneous rocks. They occur on steep side slopes of drainageways on the island of Oahu. They have an A horizon of dark reddish-brown silty clay and a silty clay B horizon that has moderate structure. Wailuku soils have an A horizon of dark-brown silty clay loam and a very sticky and very plastic silty clay B2 horizon. Both Helemano and Wailuku soils are more than 35 percent clay in the control section, have tabular

halloysitic mineralogy, and have a mean annual soil temperature of more than 72° F. Therefore, they are classified in the clayey, kaolinitic, isohyperthermic family of Tropeptic Haplustox.

Kahana soils have a dark reddish-brown A horizon that has moderate structure and a dark reddish-brown silty clay B horizon that has continuous pressure faces on peds. Because of a clayey control section that is dominated by tabular halloysite, and a mean annual soil temperature of 70° F., Kahana soils are classified in the clayey, kaolinitic, isothermic family of Tropeptic Haplustox.

Histosols

The Histosols in Hawaii are placed in the suborders Folists and Saprists.

Folists are organic soils that are never saturated with water or are saturated for only a few days at a time. They have a litter of leaves, twigs, and branches in varying stages of decomposition, ranging from fresh leaves to nearly completely humified material. In addition, they have a lithic contact less than 40 inches from the surface, or fragmental material in which the interstices are filled with organic material, or both. They do not have a mineral layer more than 4 inches thick above a lithic contact, and the organic material is more than twice the thickness of the mineral layer.

Saprists are bog soils that contain highly decomposed organic material. They occur in closed depressions where the ground water level tends to fluctuate within the soil allowing periodic aerobic decomposition. These soils have the least amount of plant fiber, the highest bulk density value, and the lowest water content at saturation of any of the three basic kinds of organic material on a dry weight basis.

Folists

Kaimu, Malama, and Opihikao soils are classified in the suborder Folists and in the great group Tropofolists. The prefix *Trop* is taken from the Greek word meaning tropical. Kaimu and Malama soils are further classified as Typic Tropofolists because they have fragmental material in which the interstices are filled with organic material in half or more of each pedon.

Kaimu soils have a thin, very dark-brown O2 horizon underlain by fragmental Aa lava. They are nonsmeary. Field moisture is less than 100 percent. Because of a neutral pH and a mean annual soil temperature of 73° F., Kaimu soils are classified as a member of the euic, isohyperthermic family of Typic Tropofolists.

Malama soils have a thin, very dark-brown O2 horizon underlain by fragmental Aa lava. They are weakly smeary. Field moisture is 130 to 175 percent. These soils have a pH of 5.4 and a mean annual soil temperature of 72° F. Therefore, they are classified as a member of the dysic, isohyperthermic family of Typic Tropofolists.

Folists that are underlain by pahoehoe lava within a depth of 40 inches are classified as Lithic Tropofolists. Opihikao soils are similar to the Malama soils but are underlain by pahoehoe lava bedrock within a depth of 20 inches. For this reason and also because they have a pH of 5.4 and a mean annual soil temperature of 72° F., Opihikao soils are classified in the dysic, isohyperthermic family of Lithic Tropofolists.

TABLE 6.—*Chemical and*

[Analyses made by Soil Survey Laboratories, SCS, Lincoln, Neb., and Riverside, Calif.,

Soil, sample number, and location	Depth	Organic carbon	Nitrogen	Free iron oxide (Fe_2O_3)	Bulk density [1]	Moisture retention [1]		Reaction		Cation exchange capacity (NH_4OAc)	Extractable bases			
						1/3 atmos.	15 atmos.	1:5 (H_2O)	1:5 (KCL)		Ca	Mg	Na	K
	In.	*Pct.*	*Pct.*	*Pct.*	*Gm./cc.*	*Pct.*	*Pct.*	*pH*	*pH*	*Meq./100 gm.*	*Meq./100 gm.*	*Meq./100 gm.*	*Meq./100 gm.*	*Meq./100 gm.*
Haiku clay: [3]	0–7	3. 08	0. 263	35. 5	1. 10	34. 7	25. 5	5. 1	4. 1	15. 9	0. 0	0. 6	0. 1	0. 3
S62 Ha-4-2 (1–7),	7–13	2. 79	. 232	34. 2	1. 13	30. 4	24. 4	5. 0	4. 0	14. 3	. 0	. 6	. 1	. 2
lat. 20°54′08″ N.,	13–18	1. 98	. 161	31. 5	1. 12	44. 2	38. 4	4. 9	4. 1	15. 5	. 2	. 8	. 2	. 1
long. 156°17′42″ W.	18–28	1. 78	. 128	35. 6	1. 06	44. 4	39. 0	5. 2	4. 4	12. 2	. 6	. 7	. 4	. 1
	28–39	1. 08	. 080	22. 9	1. 10	40. 4	33. 2	5. 1	4. 0	12. 7	1. 0	. 8	1. 0	. 1
	39–62	. 91	. 059	19. 9	1. 10	43. 2	33. 5	5. 0	4. 0	12. 0	. 6	. 2	. 8	. 1
	62–70	. 74	. 045	19. 2	------	36. 2	24. 9	4. 9	4. 0	12. 4	. 4	. 3	. 8	. 1
Hanalei silty clay:	0–6	2. 30	. 239	8. 9	. 75	63. 5	43. 8	4. 8	3. 9	33. 9	12. 5	14. 4	. 6	. 2
S62 Ha-2–1 (1–6),	6–10	1. 96	. 173	8. 9	. 96	62. 8	41. 2	5. 3	4. 1	34. 7	12. 9	16. 0	. 5	. 1
lat. 22°12′37. 8″ N.,	10–13	1. 46	. 133	9. 2	1. 01	57. 4	39. 5	6. 5	5. 2	30. 7	12. 2	15. 5	. 5	(4)
long. 159°28′47″ W.	13–18	. 84	. 095	11. 4	. 87	63. 3	42. 8	6. 6	5. 3	35. 7	12. 6	17. 2	1. 0	. 1
	18–26	. 54	. 067	15. 3	. 82	70. 1	47. 7	6. 7	5. 2	39. 9	12. 5	17. 0	1. 0	. 1
	26–36	. 42	------	13. 7	. 81	67. 8	------	6. 4	4. 9	38. 0	12. 3	17. 2	1. 0	. 1
Honouliuli clay:	0–15	. 74	. 073	10. 7	1. 30	30. 2	22. 3	7. 1	5. 8	27. 0	12. 2	12. 5	1. 4	. 5
S62 Ha-7–5 (1–5)	15–26	. 21	. 039	11. 0	1. 49	28. 1	20. 9	7. 5	6. 2	24. 9	12. 5	11. 5	1. 9	. 1
lat. 21°20′56″ N.,	26–36	. 20	. 029	11. 3	1. 48	27. 7	21. 5	8. 0	7. 0	25. 5	17. 0	11. 3	2. 1	. 1
long. 158°02′23″ W.	36–48	. 08	------	10. 9	1. 49	27. 6	21. 6	8. 2	7. 5	25. 3	17. 4	10. 9	2. 3	. 1
	48–68	. 02	------	11. 0	------	27. 2	21. 6	8. 2	7. 2	24. 6	18. 1	11. 2	2. 4	. 1

See footnotes at end of table.

Saprists

Saprists that occur in a climate in which there is a difference of less than 9° F. between the mean summer and mean winter temperatures are classified in the great group Troposaprists.

Alakai soils are on high ridges and in depressional areas atop Mt. Waialeale on the island of Kauai. They have a layer of decomposed debris and are underlain by gray mottled massive clay. Because of this inorganic layer, Alakai soils are placed in the subgroup Terric Troposaprists. They have a clayey subsoil, mixed mineralogy, a pH of less than 4.0, and a mean annual soil temperature of 56° F. Therefore, they are placed in the clayey, kaolinitic, dysic, isomesic family of Terric Troposaprists.

Laboratory Analysis of Selected Soils

Table 6 gives analytical data for 19 representative soil series in the survey area. All samples were collected from carefully selected pits. Soil fragments larger than 1 inch were discarded in the field. Fragments larger than 2 millimeters were discarded in the laboratory. Soil samples were kept moist, but all capacity measurements are reported on oven-dry basis.

The content of organic carbon was determined by the Walkley-Black wet-combustion method (1 milliequivalent $K_2Cr_2O_7$ equivalent to 3.9 milligrams carbon) (*9*).

Total nitrogen was determined by the Kjeldahl method modified by A.O.A.C. (*3*).

Free iron oxide was determined by dithionite-citrate extraction and orthophenanthroline colorimetry (*1*), modified by shaking overnight instead of heating.

Bulk density was determined from core samples oven dried at 105° C. Two samples were taken at each 3-inch increment to a depth of 60 inches. The reported values are averages for the horizons.

Moisture retention was determined at ⅓ atmosphere and 15 atmospheres using the Richards pressure membrane apparatus (*10*).

The pH was determined by glass electrode, using soil-water and soil-potassium chloride ratios of 1:5 for all except Io and Waiakoa soils, for which the ratios were 1:1 (*9*).

Cation exchange capacity was determined by direct distillation of adsorbed ammonia after saturation with ammonium acetate (*9*).

Extractable calcium, magnesium, sodium, and potassium were determined by extraction with neutral normal ammonium acetate (*9*). Calcium and magnesium were separated with alcohol and determined by EDTA titration (*4*). Sodium and potassium were determined on original extracts by using flame photometry (*6*).

Extractable aluminum was determined by extraction with neutral normal potassium chloride and fluoride titration (*19*).

Extractable sulfate was determined by extraction with neutral normal ammonium acetate and precipitation with barium sulfate by using a modification of the method devised by Richards (*11*).

Total analysis was determined by standard methods used by the Hawaii Agricultural Experiment Station of the University of Hawaii.

physical data of selected soils

except as otherwise indicated in footnotes. Dashes indicate data were not determined]

KCl extractable Al	NH_4OAc extractable SO_4	Base saturation (NH_4OAc)	Total analysis [2]											
			SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	Loss on ignition	H_2O
Meq./100 gm.	*Meq./100 gm.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
0. 5	1. 7	6	15. 9	11. 0	7. 22	43. 8	0. 14	0. 92	0	0. 06	1. 09	0. 52	14. 7	5. 42
. 5	1. 6	6	16. 0	10. 7	10. 6	40. 9	. 11	. 73	0	. 07	1. 17	. 49	14. 8	4. 85
. 4	1. 3	8	12. 8	7. 16	13. 8	38. 7	. 06	. 06	0	0	. 90	. 52	16. 0	9. 31
. 2	1. 4	15	10. 3	5. 65	20. 1	32. 0	. 08	. 68	0	. 02	. 56	. 45	16. 7	13. 3
. 8	2. 0	23	17. 1	4. 74	24. 8	25. 7	. 11	. 89	0	0	. 28	. 35	16. 5	9. 64
1. 1	4. 4	14	15. 8	5. 15	27. 5	24. 1	. 11	1. 48	0	0	. 10	. 38	16. 1	8. 66
. 8	4. 1	13	15. 7	4. 76	30. 4	22. 8	. 14	1. 42	0	0	0	. 30	16. 6	7. 65
. 2	0	82	33. 4	4. 09	19. 1	15. 9	. 10	2. 94	1. 54	. 57	. 14	. 61	13. 1	8. 66
. 1	0	85	33. 4	4. 27	20. 0	16. 0	. 09	2. 89	2. 08	. 57	. 14	. 46	12. 2	8. 01
--------	0	92	34. 3	4. 10	20. 3	16. 1	. 12	2. 84	2. 12	. 53	. 09	. 48	11. 7	8. 03
--------	0	86	32. 1	4. 11	21. 0	18. 1	. 10	2. 45	1. 69	. 52	. 13	. 48	11. 3	8. 26
--------	0	77	30. 8	4. 15	20. 3	19. 5	. 09	2. 90	1. 46	. 52	. 08	. 50	10. 6	9. 34
--------	0	80	30. 2	3. 88	19. 8	21. 1	. 11	2. 61	1. 58	. 57	. 09	. 54	10. 3	9. 27
--------	. 2	98	33. 4	4. 75	21. 7	23. 7	. 79	. 21	. 10	. 22	. 04	. 29	11. 6	6. 01
--------	. 6	100	32. 1	3. 20	20. 5	25. 7	. 71	. 13	. 10	. 21	. 03	. 24	11. 5	5. 77
--------	. 4	100	33. 5	4. 47	19. 8	23. 1	. 35	. 18	. 07	. 22	. 04	. 31	11. 6	5. 67
--------	. 5	100	30. 7	5. 40	22. 4	21. 1	. 25	1. 41	. 91	. 29	. 04	. 59	10. 8	6. 22
--------	. 5	100	30. 8	5. 07	22. 6	21. 2	. 22	1. 34	1. 33	. 33	. 04	. 58	10. 7	6. 27

TABLE 6.—*Chemical and*

Soil, sample number, and location	Depth	Organic carbon	Nitrogen	Free iron oxide (Fe_2O_3)	Bulk density [1]	Moisture retention [1] 1/3 atmos.	Moisture retention [1] 15 atmos.	Reaction 1:5 (H_2O)	Reaction 1:5 (KCL)	Cation exchange capacity (NH_4OAc)	Extractable bases Ca	Extractable bases Mg	Extractable bases Na	Extractable bases K
	In.	*Pct.*	*Pct.*	*Pct.*	*Gm./cc.*	*Pct.*	*Pct.*	*pH*	*pH*	*Meq./100 gm.*	*Meq./100 gm.*	*Meq./100 gm.*	*Meq./100 gm.*	*Meq./100 gm.*
Hoolehua silty clay:	0–9	1. 30	. 154	12. 0	1. 19	29. 2	21. 4	4. 0	3. 5	15. 6	1. 9	0. 9	0. 1	0. 8
S63 Ha–5–3 (1–6),	9–15	. 88	. 128	12. 7	1. 18	26. 2	23. 0	5. 1	4. 4	14. 6	6. 0	1. 8	. 1	. 7
lat. 21°09′34″ N.,	15–21	. 44	. 085	12. 3	1. 19	26. 1	22. 4	6. 6	5. 6	11. 2	7. 8	1. 8	. 2	. 6
long. 157°03′08″ W.	21–27	. 08	------	11. 9	1. 24	24. 2	21. 7	6. 8	5. 8	10. 4	7. 2	2. 5	. 2	. 6
	27–49	. 06	------	11. 9	1. 41	24. 1	20. 8	6. 8	5. 8	10. 1	5. 2	2. 9	. 2	. 6
	49–64	. 12	------	12. 6	1. 49	24. 5	20. 2	6. 2	5. 4	9. 8	3. 9	2. 9	. 1	. 6
Io silt loam: [3]	0–9	5. 81	. 455	12. 4	. 87	49. 9	35. 2	[5] 6. 7	[5] 5. 8	61. 1	35. 8	11. 7	. 4	6. 1
S65 Ha–4–22 (1–5)	9–16	2. 55	. 207	15. 2	. 88	50. 0	38. 1	[5] 7. 4	[5] 6. 5	65. 5	55. 5	22. 3	1. 7	4. 2
lat. 20°40′00″ N.,	16–25	2. 58	. 201	13. 7	. 75	55. 7	43. 2	[5] 7. 4	[5] 6. 4	63. 1	42. 7	12. 3	6. 0	. 3
long. 156°24′10″ W.	25–30	2. 92	. 010	3. 1	. 77	17. 7	14. 1	[5] 7. 8	[5] 6. 4	54. 3	34. 9	11. 7	2. 2	. 9
	30–39	. 79	. 072	15. 2	. 76	58. 1	51. 3	[5] 7. 5	[5] 6. 5	56. 7	39. 9	13. 7	6. 0	. 2
Kalae silty clay:	0–9	3. 35	. 363	23. 7	1. 25	29. 8	19. 3	6. 3	5. 3	17. 6	5. 6	2. 2	. 1	. 6
S63 Ha–5–1 (1–7),	9–15	. 61	. 134	26. 7	1. 54	20. 2	16. 1	6. 5	5. 5	7. 9	2. 6	1. 5	. 1	. 6
lat. 21°10′28″ N.,	15–26	. 58	. 100	32. 5	1. 53	27. 9	23. 4	6. 6	5. 5	11. 7	3. 3	3. 1	. 5	1. 2
long. 157°02′37″ W.	26–41	. 87	. 110	28. 6	1. 25	32. 3	28. 6	5. 4	4. 3	14. 8	2. 0	3. 1	. 6	1. 3
	41–53	1. 52	. 112	16. 6	1. 12	47. 2	38. 9	4. 7	4. 0	21. 1	. 7	1. 6	. 7	. 9
	53–62	1. 07	. 071	11. 3	1. 15	40. 6	33. 9	4. 5	3. 7	15. 6	. 5	1. 1	1. 1	. 3
	62–67	. 62	. 044	7. 4	------	34. 7	28. 1	4. 5	3. 4	13. 8	. 6	1. 1	1. 5	. 2
Kapaa silty clay: [3]	0–12	3. 92	. 217	34. 5	1. 13	36. 3	30. 0	5. 0	4. 5	15. 9	. 7	. 4	. 2	. 4
S65 Ha–2–5 (1–6),	12–16	1. 46	. 065	33. 3	1. 07	40. 1	35. 6	5. 5	5. 7	3. 7	. 2	(4)	. 1	. 2
lat. 22°01′34″ N.,	16–25	1. 09	. 044	30. 5	1. 05	37. 3	30. 5	5. 5	5. 7	2. 6	. 4	. 1	. 2	. 1
long. 159°23′50″ W.	25–36	. 64	. 023	26. 5	1. 12	38. 4	32. 1	5. 8	5. 7	1. 9	. 1	. 1	. 2	. 1
	36–49	. 46	. 019	24. 5	1. 16	38. 9	31. 7	5. 3	5. 4	3. 7	. 8	. 1	. 2	. 1
	49–60	. 48	. 019	24. 6	------	40. 5	34. 8	5. 5	4. 9	6. 1	1. 0	. 1	. 3	. 1
Keahua silty clay loam:	0–5	1. 09	. 138	12. 3	1. 12	26. 7	22. 2	5. 6	4. 7	15. 6	6. 2	2. 6	. 2	. 5
S63 Ha–4–4 (1–6A,	5–10	1. 10	. 129	13. 9	1. 14	25. 8	22. 1	5. 7	4. 8	14. 3	6. 4	2. 7	. 2	. 2
6B, 7), lat.	10–15	. 58	. 094	14. 2	1. 23	27. 5	22. 3	6. 3	5. 4	10. 2	5. 1	1. 8	. 1	(4)
20°49′56″ N., long.	15–24	. 45	. 080	13. 9	1. 27	28. 9	22. 1	6. 4	5. 6	8. 8	4. 2	1. 7	. 2	(4)
156°23′50′ W.	24–33	. 28	------	12. 6	1. 35	28. 0	23. 6	6. 7	5. 8	10. 2	4. 6	2. 2	. 5	(4)
	33–48	. 17	------	9. 0	1. 32	29. 3	25. 1	6. 7	5. 5	14. 4	5. 1	2. 8	2. 0	(4)
	48–62	. 23	------	6. 7	1. 25	------	------	6. 3	5. 4	13. 7	4. 3	3. 2	2. 6	(4)
	0–11	3. 00	. 236	20. 4	. 94	49. 6	36. 0	4. 3	3. 8	15. 6	0	. 6	. 1	. 1
Lawai silty clay: [3]	11–22	1. 91	. 166	24. 2	. 93	63. 6	48. 6	4. 8	4. 1	13. 7	0	1. 0	. 1	. 1
S63 Ha–2–5 (1–5),	22–39	1. 18	. 106	24. 2	. 91	64. 9	51. 3	4. 9	4. 1	15. 9	. 8	1. 4	. 2	. 1
lat. 21°58′15″ N.,	39–58	. 83	. 773	26. 3	. 93	68. 1	51. 7	4. 9	3. 9	15. 6	. 8	1. 4	. 4	. 1
long. 159°30′21″ W.	58–64	. 58	. 048	22. 2	------	55. 0	39. 7	4. 8	3. 8	14. 1	. 7	1. 1	. 7	. 1
Lihue silty clay:	0–6	2. 66	. 273	18. 6	. 96	46. 1	33. 8	5. 5	5. 0	19. 1	6. 8	4. 4	. 2	. 8
S62 Ha–2–7 (1–6),	6–12	2. 00	. 213	18. 4	1. 03	46. 0	33. 6	5. 5	4. 9	17. 3	5. 3	3. 3	. 1	. 3
lat. 21°59′06.7″ N.,	12–21	. 45	. 086	20. 6	1. 13	39. 7	32. 3	6. 3	6. 0	7. 9	3. 0	1. 9	. 2	. 2
long. 159°21′50″ W.	21–27	. 37	------	21. 2	1. 21	38. 4	33. 0	6. 6	6. 2	7. 3	2. 7	1. 5	. 1	. 1
	27–48	. 42	------	22. 6	1. 21	39. 6	34. 2	6. 6	6. 2	7. 4	3. 0	1. 2	. 2	. 1
	48–60	. 44	------	23. 2	1. 19	40. 3	35. 0	6. 6	6. 2	8. 3	3. 6	1. 7	. 4	. 1
Lualualei clay:	0–1	. 66	. 082	10. 4	1. 29	31. 8	22. 0	7. 1	5. 9	34. 1	17. 1	15. 2	. 8	1. 4
S62 Ha–7–1 (1–6),	1–10	. 42	. 060	10. 0	1. 40	30. 0	22. 1	7. 2	5. 4	32. 9	15. 1	15. 1	1. 3	. 4
lat. 21°25′10″ N.,	10–22	. 21	. 054	10. 7	1. 54	28. 4	22. 7	7. 2	5. 4	32. 9	14. 6	13. 4	2. 5	. 2
long. 158°09′00″ W.	22–30	. 17	. 044	10. 4	1. 55	27. 8	21. 4	6. 8	5. 2	32. 1	16. 0	10. 5	3. 9	. 2
	30–49	. 17	------	9. 4	1. 54	28. 4	22. 3	5. 6	4. 9	29. 8	73. 1	9. 3	7. 2	. 2
	49–54	. 16	------	8. 6	1. 42	34. 5	25. 3	5. 8	5. 0	30. 6	73. 8	10. 7	8. 4	. 3
Mahana silty clay loam:	0–7	6. 15	. 413	31. 0	1. 22	41. 7	36. 7	5. 6	4. 7	27. 1	6. 1	2. 8	. 2	1. 0
S65 Ha–2–2 (1–6),	7–11	5. 18	. 289	27. 3	. 94	48. 5	38. 9	5. 4	4. 7	22. 6	1. 1	. 6	. 2	. 4
lat. 22°01′30″ N.,	11–20	5. 40	. 267	25. 6	. 73	58. 3	42. 6	5. 2	4. 8	19. 4	. 2	. 1	. 2	. 2
long. 159°41′11″ W.	20–35	3. 78	. 198	17. 1	. 70	65. 6	44. 6	4. 7	4. 7	17. 3	0	(4)	. 1	. 1
	35–48	2. 04	. 109	16. 0	. 98	49. 8	39. 4	4. 9	4. 6	15. 4	0	(4)	. 1	. 1
	48 61	. 94	. 052	16. 6	------	39. 1	35. 1	5. 0	4. 3	15. 5	. 2	. 3	. 2	. 1

See footnotes at end of table.

physical data of selected soils—Continued

KCl extractable Al	NH_4OAc extractable SO_4	Base saturation (NH_4OAc)	Total analysis [2]											
			SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	KO_2	P_2O_5	Loss on ignition	H_2O
Meq./100 gm.	*Meq./100 gm.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
2.2	4.7	24	25.0	4.49	25.8	19.9	1.43	1.54	.62	0.15	1.09	2.70	13.1	4.53
.2	1.9	59												
--------	1.0	93	25.8	4.37	26.4	20.4	1.26	1.68	.70	.14	1.05	2.42	11.8	4.40
--------	1.4	100												
--------	1.5	88	26.8	3.98	27.4	19.6	.71	1.62	1.06	.16	1.03	2.98	11.1	4.40
--------	1.7	76												
--------	0	88	25.5	3.60	18.2	15.6	.28	4.08	2.20	.41	.50	.65	16.6	12.9
--------	0	100	25.4	3.70	18.4	16.4	.28	4.06	2.11	.39	.34	.60	14.4	14.9
--------	0	97	24.2	3.78	18.4	16.3	.23	3.51	1.66	.38	.19	.50	13.0	18.2
--------	0	92	38.2	3.77	14.8	14.3	.21	7.32	7.29	1.71	.59	.47	4.82	7.30
--------	0	100	27.3	4.05	19.6	17.9	.20	4.21	1.25	.28	.11	.23	10.7	14.8
--------	.3	48	16.0	10.8	10.9	40.0	.38	2.35	[4]	.07	1.23	.85	12.0	5.81
--------	.3	61	15.7	11.3	14.2	44.7	.34	2.10	[4]	.05	1.34	.74	7.51	2.82
--------	.3	69	19.5	6.78	17.9	35.8	.14	1.13	[4]	.07	1.25	.90	10.8	6.19
.2	1.5	47	20.3	3.90	23.4	27.9	.08	.85	[4]	.05	.95	.85	13.9	8.07
1.6	2.8	18	19.7	3.47	26.2	18.6	.08	.58	0	.04	.47	.83	17.0	12.9
2.2	3.3	19	21.3	4.01	29.0	17.0	.14	.82	0	.03	.22	.55	16.6	10.2
2.4	2.4	25	25.6	3.71	30.6	13.9	.13	.62	0	0	0	.53	15.3	9.46
.6	1.8	11	6.08	6.71	21.8	34.2	.05	.28	[4]	.03	.25	.56	19.2	11.5
--------	4.7	14	3.94	6.39	24.9	34.7	.08	.22	0	.03	.10	.49	17.6	11.6
--------	7.6	31	3.70	7.19	25.7	34.5	.07	.07	0	.03	.06	.52	17.6	10.7
--------	12.0	26	3.94	6.76	29.8	31.1	.15	.12	0	.03	.06	.57	18.1	9.32
.1	4.4	32	6.48	6.84	28.1	32.0	.14	.10	0	.03	.06	.52	17.2	8.96
--------	11.6	24	11.6	7.36	21.7	32.2	.13	.33	[4]	.03	.06	.53	13.6	12.4
.1	.1	61	28.3	5.08	27.9	20.2	.47	1.15	.02	.18	.35	.41	11.6	4.25
0	[4]	66	28.8	5.09	28.0	20.2	.49	.95	.03	.16	.30	.44	11.9	4.20
--------	.1	69	28.0	5.03	28.8	20.9	.45	1.14	.03	.16	.29	.27	11.1	3.99
--------	.2	69	27.7	5.23	29.0	20.9	.36	1.09	.02	.17	.28	.41	11.0	4.39
--------	.4	72	27.4	5.26	28.7	21.0	.32	1.14	.02	.15	.20	.33	10.7	5.35
--------	.3	69	29.2	6.42	24.3	20.7	.28	1.06	.02	.15	.05	.19	10.4	7.44
--------	.3	74	28.2	6.09	25.5	20.3	.26	1.24	.01	.17	.06	.22	10.2	7.75
2.2	2.8	5	18.3	7.90	22.5	28.9	.07	.74	0	.07	.99	.29	15.4	5.94
.6	2.1	9	17.3	5.58	25.0	28.8	.09	.62	.06	.07	.78	.26	16.1	5.48
1.2	2.8	10	18.2	4.30	26.4	27.8	.10	.60	0	.04	.47	.26	15.5	6.12
3.6	4.5	17	20.9	3.75	25.4	26.4	.07	.58	[4]	.04	.28	.23	15.1	7.10
4.9	6.1	18												
[4]	.3	64	21.1	4.20	28.5	20.8	1.16	.95	.08	.18	1.11	.56	17.0	4.20
--------	.1	52	20.8	4.00	29.7	19.9	1.35	1.04	[4]	.16	1.11	.60	16.3	4.72
--------	1.0	67	23.8	4.40	30.7	21.8	.50	.56	[4]	.21	1.09	.32	13.5	3.78
--------	.9	60	22.8	4.75	29.1	22.9	.23	.62	[4]	.19	1.08	.37	13.2	3.80
--------	.9	61	24.2	5.38	28.0	24.0	.15	.45	[4]	.18	.78	.37	12.5	3.84
--------	.8	70	23.1	5.75	27.2	25.5	.12	.07	[4]	.15	.51	.40	12.4	4.68
--------	.9	100	28.5	7.20	18.0	24.5	.28	1.40	1.47	.24	.07	.47	10.9	7.05
--------	.1	97	29.6	7.08	19.0	24.1	.31	1.39	1.60	.26	.07	.45	10.1	7.27
--------	.1	93	31.8	7.04	17.8	24.6	.42	1.47	.58	.27	.05	.48	10.2	6.79
--------	1.3	95	31.3	7.09	18.3	24.1	.40	1.61	.32	.35	.06	.34	9.84	7.10
--------	61.2	--------	22.0	5.74	18.6	22.5	.31	1.47	2.38	.41	.04	.35	10.6	7.68
--------	63.7	--------	29.1	6.06	18.8	20.6	.35	1.38	4.05	.45	.06	.27	10.7	8.38
.3	.2	37	16.1	6.97	15.2	35.6	.10	.76	.10	.04	.36	.50	16.7	7.58
.9	.2	10	14.2	4.74	19.7	26.4	.03	.47	[4]	.04	.28	.37	16.8	17.0
1.0	0	4	14.9	4.12	20.6	23.4	.05	.46	[4]	.04	.23	.37	19.6	16.4
.8	.7	1	19.1	3.70	24.0	18.2	.07	.36	[4]	.03	.11	.32	18.5	16.1
1.3	.7	1	23.1	3.41	26.2	19.1	.07	.44	.04	.03	.07	.33	16.5	10.9
5.6	.7	5	26.6	2.32	26.6	21.0	.05	.48	[4]	.04	.06	.27	13.4	8.14

TABLE 6.—*Chemical and*

Soil, sample number, and location	Depth	Organic carbon	Nitrogen	Free iron oxide (Fe_2O_3)	Bulk density [1]	Moisture retention [1] 1/3 atmos.	Moisture retention [1] 15 atmos.	Reaction 1:5 (H_2O)	Reaction 1:5 (KCL)	Cation exchange capacity (NH_4OAc)	Extractable bases Ca	Extractable bases Mg	Extractable bases Na	Extractable bases K
	In.	*Pct.*	*Pct.*	*Pct.*	*Gm./cc.*	*Pct.*	*Pct.*	*pH*	*pH*	*Meq./100 gm.*	*Meq./100 gm.*	*Meq./100 gm.*	*Meq./100 gm.*	*Meq./100 gm.*
Makapili silty clay:	0–12	4. 90	. 387	31. 7	1. 01	41. 5	31. 8	5. 9	4. 5	21. 0	1. 5	2. 3	0. 3	0. 3
S63 Ha–2–4 (1–6),	12–14	2. 60	. 166	38. 9	1. 09	------	------	5. 1	4. 4	15. 3	. 5	. 9	. 2	. 1
lat. 22°13′14″ N.,	14–22	2. 51	. 147	40. 2	1. 00	39. 2	34. 8	5. 1	4. 5	14. 2	. 6	. 8	. 2	. 1
long. 159°28′46.9″	22–28	2. 11	. 118	43. 2	1. 13	40. 4	33. 7	5. 3	4. 9	12. 3	. 4	. 8	. 2	(4)
W.	28–44	. 98	------	35. 2	1. 29	32. 7	24. 6	4. 9	5. 3	5. 8	------	. 4	. 1	(4)
	44–60	. 78	------	38. 6	1. 19	34. 4	30. 1	4. 5	4. 8	3. 7	------	. 2	. 1	(4)
Nohili clay: [3]	0–14	1. 42	. 142	8. 3	1. 09	44. 6	34. 9	8. 7	7. 4	40. 7	29. 3	28. 0	1. 7	. 3
S63 Ha–2–8 (1–7),	14–22	. 91	. 102	10. 2	1. 08	42. 2	33. 6	8. 5	7. 3	44. 8	22. 8	24. 6	2. 0	. 2
lat. 21°22′42″ N.,	22–31	1. 33	. 128	4. 9	. 99	64. 1	43. 9	8. 8	7. 4	54. 6	36. 8	40. 8	3. 0	. 3
long. 159°45′18″ W.	31–37	. 59	. 065	2. 4	------	58. 6	38. 9	8. 8	7. 5	48. 8	37. 0	39. 8	2. 4	. 2
	37–46	. 27	------	1. 1	------	38. 4	26. 7	8. 9	7. 6	28. 2	33. 5	27. 9	1. 4	. 2
	46–55	. 17	------	. 9	------	------	------	8. 9	7. 7	30. 0	34. 1	28. 5	1. 6	. 2
	55–60	. 14	------	1. 4	------	------	------	8. 8	7. 5	42. 4	40. 2	35. 4	3. 0	. 4
Paaloa silty clay:	0–17	2. 43	. 166	25. 9	1. 27	32. 4	26. 4	4. 8	4. 4	14. 2	2. 0	. 2	. 2	. 2
S65 Ha–7–1 (1–5),	17–25	. 95	. 045	20. 0	1. 29	30. 5	25. 5	4. 7	4. 4	7. 6	0	0	. 2	. 1
lat. 21°36′02″ N.,	25–36	. 75	. 032	17. 4	1. 21	36. 1	30. 5	4. 8	4. 3	6. 2	. 2	(4)	. 2	. 1
long. 158°01′30″	36–45	. 78	------	19. 3	1. 15	36. 1	31. 3	4. 6	4. 3	7. 2	. 7	. 1	. 2	. 1
W.	45–60	. 79	------	20. 9	1. 08	39. 1	33. 4	4. 7	4. 3	14. 6	. 8	. 4	. 4	. 1
Pane silt loam:	0–8	8. 87	. 686	16. 3	. 70	64. 6	41. 0	6. 2	5. 4	53. 7	17. 5	6. 3	. 3	1. 7
S65 Ha–4–23 (1–6),	8–16	3. 51	. 299	14. 3	. 64	67. 1	49. 1	6. 6	5. 8	40. 6	11. 8	5. 4	. 4	1. 8
lat. 20°49′30″ N.	16–29	2. 57	. 211	14. 2	. 84	50. 6	40. 6	7. 1	5. 8	36. 6	7. 8	4. 7	. 7	. 9
long. 156°18′40″	29–39	1. 57	. 133	10. 7	. 94	51. 5	38. 6	6. 1	5. 4	25. 6	6. 1	2. 4	1. 5	. 5
W.	39–57	. 86	. 072	8. 6	------	41. 2	34. 9	6. 2	5. 2	29. 8	3. 0	3. 6	2. 2	1. 6
	57–65	. 29	------	5. 1	------	38. 6	28. 7	6. 2	5. 2	20. 3	. 2	4. 3	1. 4	4. 0
Puhi silty clay loam: [3]	0–9	4. 39	. 370	23. 6	. 91	46. 3	34. 2	5. 9	4. 9	19. 8	2. 2	2. 0	. 2	. 8
S63 Ha–2–2 (1–6),	9–21	1. 72	. 140	28. 0	. 92	50. 5	40. 3	5. 4	5. 4	9. 4	1. 0	. 6	. 2	. 2
lat. 22°03′30″ N.,	21–30	1. 27	. 084	29. 5	. 98	49. 2	42. 2	5. 8	5. 8	10. 8	1. 1	. 6	. 6	. 1
long. 159°22′30″	30–39	. 62	------	26. 3	1. 10	44. 1	38. 8	6. 0	5. 9	7. 2	. 9	. 8	. 9	. 1
W.	39–48	. 52	------	26. 2	1. 14	41. 1	34. 5	5. 8	5. 7	5. 9	. 9	. 9	1. 0	. 1
	48–60	. 41	------	24. 9	1. 15	44. 1	33. 2	5. 6	5. 3	6. 8	1. 0	. 8	1. 3	. 1
Waiakoa silty clay loam:	0–2	1. 59	. 130	11. 4	1. 30	27. 2	20. 9	[5] 6. 1	[5] 5. 3	16. 0	7. 8	4. 0	. 2	2. 5
S65 Ha–4–2b (1–5),	2–8	. 82	. 066	10. 7	1. 21	25. 6	19. 4	[5] 6. 2	[5] 5. 2	14. 7	6. 6	3. 1	. 3	2. 3
lat. 20°47′20″ N.,	8–16	. 80	. 066	10. 6	1. 14	26. 4	20. 2	[5] 6. 1	[5] 5. 2	13. 8	6. 1	2. 9	. 5	. 9
long. 156°24′30″	16–25	. 57	. 053	7. 4	1. 08	34. 2	23. 2	[5] 6. 6	[5] 5. 2	14. 7	5. 6	2. 8	1. 3	. 2
W.	25–33	. 28	------	5. 1	------	40. 6	23. 3	[5] 7. 1	[5] 5. 8	19. 2	8. 2	3. 9	2. 5	. 1
Waihuna clay: [3]	0–4	1. 11	. 132	13. 0	------	34. 3	26. 6	5. 0	4. 0	20. 0	8. 9	3. 7	. 2	. 6
S62 Ha–3–1 (1–6),	4–17	1. 51	. 168	13. 0	------	35. 6	28. 9	4. 5	3. 6	22. 8	6. 4	2. 4	. 1	. 5
lat. 20°49′39″ N.,	17–23	. 40	. 080	13. 4	------	35. 5	29. 4	5. 9	5. 0	20. 4	9. 5	4. 9	. 2	1. 3
long. 156°55′41″	23–37	. 29	------	13. 9	------	36. 5	30. 8	6. 0	5. 1	19. 8	8. 3	7. 6	. 4	1. 0
W.	37–54	. 16	------	14. 2	------	36. 9	31. 4	4. 7	3. 6	18. 0	3. 6	7. 8	. 5	. 3
	54–64	. 22	------	13. 6	------	35. 5	30. 2	4. 8	3. 7	19. 4	5. 3	8. 6	. 5	. 4

[1] Bulk density and moisture retention values were determined by Hawaii Sugar Planters Association, Honolulu.
[2] Total analysis was determined by Hawaii Agricultural Experiment Station, Univ. of Hawaii, Honolulu.
[3] Data is for the paired sample of the soil profile described in the section "Descriptions of the Soils."

physical data of selected soils—Continued

KCl extractable Al	NH_4OAc extractable SO_4	Base saturation (NH_4OAc)	Total analysis [2]											
			SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	Loss on ignition	H_2O
Meq./100 gm.	*Meq./100 gm.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
0.2	0.6	21	10.9	6.59	22.0	31.8	0.08	0.64	0.03	0.09	1.04	0.57	20.5	7.14
.2	1.2	11	----	----	----	----	----	----	----	----	----	----	----	----
.1	1.6	12	7.30	5.56	18.2	41.8	.05	.36	(4)	.08	.76	.57	18.0	9.34
(4)	2.8	11	4.14	5.93	21.8	40.3	.05	.28	(4)	.07	.56	.54	18.7	7.56
(4)	9.4	9	1.88	5.89	28.5	37.4	.09	.30	(4)	.05	.24	.56	20.2	5.00
(4)	16.2	8	----	----	----	----	----	----	----	----	----	----	----	----
----	.2	100	33.7	3.50	18.9	17.9	.23	2.68	1.78	.28	.18	.29	12.1	8.68
----	.2	100	33.7	3.55	20.5	19.6	.26	2.64	1.22	.30	.16	.29	11.2	7.16
----	.4	100	34.9	2.82	16.9	14.2	.09	3.48	3.82	.25	.14	.24	14.3	9.94
----	.5	100	----	----	----	----	----	----	----	----	----	----	----	----
----	.3	100	----	----	----	----	----	----	----	----	----	----	----	----
----	0	100	----	----	----	----	----	----	----	----	----	----	----	----
----	.6	100	----	----	----	----	----	----	----	----	----	----	----	----
.8	.3	18	19.3	9.52	21.2	28.3	.09	.80	(4)	.11	1.58	.34	13.9	5.06
1.8	1.0	4	13.1	5.71	33.2	24.4	.08	.32	(4)	.04	.38	.23	18.9	3.32
1.3	13.9	8	12.5	5.36	35.4	23.7	.10	.28	(4)	.06	.22	.27	18.9	3.24
1.2	3.4	15	15.5	5.71	32.6	24.5	.08	.37	0	.03	.19	.32	17.6	3.06
1.2	1.6	12	16.4	5.72	29.8	27.0	.06	.35	0	.03	.16	.33	16.7	3.46
.2	0	48	17.3	3.88	20.2	17.8	.54	1.16	.63	.08	.59	.95	23.2	14.1
----	0	23	16.9	3.67	24.9	16.0	.41	.94	.32	.06	.46	.74	17.8	18.2
----	0	38	17.5	3.06	25.7	16.3	.41	.98	.15	.06	.39	.76	16.5	18.4
----	0	41	20.4	3.22	26.8	16.6	.34	.92	.20	.22	.29	.61	15.3	15.5
----	.2	35	24.9	3.28	29.1	15.3	.30	1.16	.04	.13	.25	.49	14.3	11.2
----	.4	49	----	----	----	----	----	----	----	----	----	----	----	----
.2	.8	26	16.4	4.23	31.2	28.1	.17	1.92	(4)	.10	.71	.60	12.3	5.81
.1	2.8	21	17.4	4.69	31.9	32.0	.08	1.52	(4)	.08	.50	.49	80.5	2.55
----	1.6	22	20.8	5.40	21.1	32.5	.09	1.32	0	.10	.31	.54	11.4	5.70
----	3.4	38	20.3	5.01	19.5	31.2	.10	.45	0	.10	.14	.44	14.6	7.58
----	5.6	49	15.2	4.78	27.5	30.4	.09	.56	0	.12	.10	.48	15.8	5.33
----	7.6	47	17.4	4.48	25.5	30.8	.13	.47	0	.08	.08	.58	14.7	5.98
----	0	91	26.8	5.07	28.7	20.2	.28	1.22	.27	.14	.33	.37	12.6	4.38
----	0	84	26.2	4.96	29.9	20.1	.28	1.11	.18	.14	.33	.34	11.9	4.72
----	0	75	26.3	5.36	29.0	20.8	.28	1.13	0	.14	.25	.34	12.3	4.38
----	0	67	26.2	4.41	29.6	20.4	.24	1.32	0	.18	.03	.44	12.4	5.24
----	0	76	----	----	----	----	----	----	----	----	----	----	----	----
.2	1.6	67	28.7	3.84	24.7	21.3	.77	.80	.82	.13	.05	.19	13.2	6.78
1.9	1.9	41	28.5	3.77	24.0	21.2	.81	.66	.96	.14	.04	.24	13.9	7.32
.1	1.2	78	28.8	3.66	22.6	22.6	1.20	.88	1.20	.12	.04	.22	12.5	7.04
(4)	1.7	87	28.6	3.58	23.4	22.5	.91	.85	1.17	.08	.06	.22	11.8	7.49
1.4	3.7	68	30.2	3.64	23.1	22.2	.62	.83	.84	.07	.03	.19	12.0	7.02
.6	4.6	76	30.1	3.91	23.6	23.2	.42	.66	.49	.06	.04	.17	11.5	6.71

[4] Trace.
[5] Determined in 1:1 ratio of soil to water and soil to potassium chloride.

General Nature of the Islands

This section contains general information about the history of the islands, the geology and physiography, the climate, the population, the transportation, the tourist industry, and the farms and ranches.

History

Little is known about the Hawaiian Islands before 1778 when Captain James Cook first sighted Oahu and Kauai. At the time of Cook's visit, the islands were divided into four kingdoms. Kamehameha, a chief, was rising to power on the island of Hawaii. By 1810, he had united all the islands into one kingdom.

Missionaries arrived from New England in 1820. They transcribed the spoken Hawaiian language into writing, translated hymns and parts of the Bible into Hawaiian, and taught the natives to read and write.

In 1835, the sugar industry was established at Koloa, Kauai. With increasing acreage and production, the need for additional labor increased. In 1852, Chinese immigrants arrived to work in the sugar fields. They were the first of a long list of immigrants, including Chinese, Japanese, Portugese, Koreans, Germans, and Filipinos.

The pineapple industry was established near the turn of the century in Wahiawa, Oahu.

In 1900, Hawaii became a territory of the United States, and in 1959, it officially became the 50th State.

Geology and Physiography

The area surveyed consists of five of the eight major islands in the State of Hawaii. These five islands form a chain that extends in a northwest-southeast direction. They are the summits of volcanic domes built up from the ocean floor through countless eruptions. In general, the volcanic activity moved from northwest to southeast. Kauai, on the northwest, is therefore the oldest island in the survey area, and the eastern part of Maui on the southeast is the youngest.

The islands formed primarily in thin-bedded pahoehoe and Aa lava flows. The rocks are mostly basaltic; the basalt is about 50 percent silica. Andesitic rocks as well as volcanic ash and cinders occur in a few places. Adjacent to the ocean is a small amount of coral limestone and coral sand.

The relief of the islands varies. The once smooth volcanic domes have been weathered and eroded. The older islands are deeply dissected; their surface is one of ridges, valleys, and alluvial fans. In contrast, the eastern part of Maui is relatively smooth, and the original shape of the volcano is still apparent.

Climate[7]

The climate of Hawaii is unusually pleasant for the tropics. Its outstanding features are the remarkable differences in rainfall over short distances, the mild temperatures, and the persistence of the northeasterly trade winds.

The major climatic influences in this region are the latitude—the State lies well within the geographic tropics; the surrounding ocean, which has a moderating influence on temperature; and the Pacific anticyclone, from which the trade winds flow. Between about October and April, storms that migrate eastward across the Pacific north of Hawaii, or the storms that form nearby, occasionally bring in spells of bad weather and widespread heavy rains.

The most important influence on all the weather elements is Hawaii's topography. Elevations range from sea level along the coastal plains to heights of about 5,170 feet on Kauai, 4,025 feet on Oahu, 10,025 feet on Maui, 4,970 feet on Molokai, and 3,370 feet on Lanai. More important than mere elevation, moreover, is the ruggedness of the terrain, in which each valley bottom, slope, and steep-sided ridge has its own local climate.

Rainfall.—Over the open sea in the Hawaiian area, rainfall averages between 25 and 30 inches a year. Yet the State itself receives more than 10 times this amount in some places, and less than half in others. Except for Lanai, where maximum rainfall is about 50 inches, each of the major islands has regions in which the mean annual rainfall approaches or exceeds 300 inches. Mt. Waialeale, on the island of Kauai, which has 486 inches of rain a year and is known as the wettest spot on earth, is only 15 miles from Barking Sands, which receives less than 20 inches annually. Table 7 gives precipitation data for six selected stations.

The principal cause of this remarkable variability is the orographic, or mountain-caused, rain that forms within the moist air from trade winds as it ascends and traverses the steep and high terrain of the islands. The resulting rainfall distribution, in the mean, closely resembles the topographic contours. The amount is greatest over windward slopes and crests and is least toward the leeward lowlands.

The lowlands obtain moisture chiefly from a few winter storms, and only negligibly from trade-wind showers. Thus, rainfall in the normally dry areas is strongly seasonal. Summers are arid. Seasonal differences are much smaller in the wetter areas, where rainfall is derived from both the winter storms and the year-round, trade-wind showers. For example, at Kaunakakai, a very dry station where the mean annual rainfall 12.5 inches, June and July together account on the average for less than 1 percent of the annual rainfall; but in Wahiawa where rainfall measures 50 inches a year, June and July account for 10 percent, and in Kahana where it measures 240 inches a year, they account for 17 percent. No data from the Kahana station are given in table 7.

The number of rainy days a year also varies widely from place to place; the number is greatest in areas where the mean annual rainfall is higher. Kaunakakai, for example, receives 0.1 inch or more of rainfall on an average of 15 days a year and 0.5 inch or more on only 6 days. In contrast, Wahiawa receives 0.1 inch or more on an average of 81 days a year and 0.5 inch or more on 25 days. Kahana receives 0.1 inch or more on an average of 200 days a year and 0.5 inch or more on 65 days.

Another source of rainfall is the deep cumulus clouds that build up over mountains and interiors on clear calm afternoons. Although such convective showers may be

[7] By Saul Price, regional climatologist, National Weather Service, U.S. Department of Commerce.

TABLE 7.—*Precipitation data for selected stations*

[Dashes indicate no data available for specified amount of precipitation]

KILAUEA FIELD 17, KAUAI NO. 1135

[Period of record 1931–67. Mean annual precipitation 93.14 inches]

Month	Percent frequency of indicated amount							Mean monthly
	0.50 inch or less	0.51–1 inch	1.01–3 inches	3.01–5 inches	5.01–10 inches	10.01–20 inches	More than 20 inches	
	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	In.
January	0	0	16	14	38	27	5	10. 09
February	0	0	7	22	51	14	5	8. 18
March	0	0	5	11	43	32	7	9. 88
April	0	0	7	27	38	19	7	7. 81
May	0	0	11	5	70	7	5	7. 59
June	0	3	22	35	35	5	0	5. 05
July	0	0	5	27	59	7	0	6. 71
August	0	0	3	16	65	16	0	7. 69
September	0	3	27	24	41	5	0	5. 28
October	0	3	5	24	46	22	0	7. 07
November	0	0	5	19	43	27	5	8. 28
December	0	0	0	11	51	35	3	9. 51

KANEOHE (MAUKA), OAHU NO. 781

[Period of record 1931–60. Mean annual precipitation 65.09 inches]

Month	0.50 inch or less	0.51–1 inch	1.01–3 inches	3.01–5 inches	5.01–10 inches	10.01–20 inches	More than 20 inches	Mean monthly
January	0	0	20	20	37	23	0	7. 30
February	0	0	10	33	43	7	7	7. 22
March	0	0	20	33	23	23	0	7. 26
April	0	0	30	23	33	13	0	5. 53
May	0	0	40	33	20	7	0	4. 55
June	0	7	50	37	3	3	0	2. 94
July	0	3	40	23	27	7	0	4. 31
August	0	3	27	37	33	0	0	4. 29
September	0	3	43	27	27	0	0	3. 81
October	0	3	37	17	30	13	0	5. 75
November	0	0	30	20	43	7	0	5. 28
December	0	0	10	27	47	17	0	6. 85

WAHIAWA, OAHU NO. 872

[Period of record 1931–60. Mean annual precipitation 51.5 inches]

Month	0.50 inch or less	0.51–1 inch	1.01–3 inches	3.01–5 inches	5.01–10 inches	10.01–20 inches	More than 20 inches	Mean monthly
January	3	7	20	23	30	10	7	6. 47
February	0	3	17	20	47	10	3	6. 42
March	0	0	23	36	20	17	3	6. 29
April	0	3	57	23	13	0	3	3. 57
May	7	7	60	17	10	0	0	2. 49
June	0	10	70	17	3	0	0	2. 49
July	0	3	63	23	10	0	0	2. 75
August	3	3	47	20	27	0	0	3. 59
September	7	3	73	17	0	0	0	2. 24
October	3	3	57	13	10	13	0	4. 15
November	3	3	27	27	30	10	0	4. 84
December	0	0	33	13	36	17	0	6. 17

See footnotes at end of table.

TABLE 7.—*Precipitation data for selected stations*—Continued

WAIAWA, OAHU NO. 836 [1]

[Period of record 1931–60. Mean annual precipitation 138.79 inches]

Month	Percent frequency of indicated amount: 0.50 inch or less	0.51–1 inch	1.01–3 inches	3.01–5 inches	5.01–10 inches	10.01–20 inches	More than 20 inches	Mean monthly
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*In.*
January				23	23	40	13	11.64
February				10	50	27	[2] 10	12.94
March				13	10	63	13	13.84
April				7	37	50	7	11.40
May				10	33	50	7	11.84
June				7	33	57	3	10.84
July				0	20	67	13	13.30
August				0	27	60	13	4.41
September				13	40	43	3	9.97
October				13	33	43	10	11.02
November				13	27	53	7	12.10
December				3	30	43	23	15.49

KAUNAKAKAI, MOLOKAI NO. 536

[Period of record 1933–62. Mean annual precipitation 12.5 inches]

Month	0.50 inch or less	0.51–1 inch	1.01–3 inches	3.01–5 inches	5.01–10 inches	10.01–20 inches	More than 20 inches	Mean monthly
January	23	10	33	10	23	0		2.58
February	40	13	27	17	3	0		1.74
March	37	10	30	13	7	3		1.99
April	70	13	7	7	3	0		.74
May	77	7	13	3	0	0		.40
June	97	3	0	0	0	0		.03
July	97	0	3	0	0	0		.07
August	80	10	10	0	0	0		.22
September	83	13	3	0	0	0		.14
October	63	3	20	7	7	0		1.22
November	50	10	27	7	3	3		1.57
December	30	20	30	13	7	0		1.75

MAUNALOA, MOLOKAI NO. 511

[Period of record 1933–62. Mean annual precipitation 27.84 inches]

Month	0.50 inch or less	0.51–1 inch	1.01–3 inches	3.01–5 inches	5.01–10 inches	10.01–20 inches	More than 20 inches	Mean monthly
January	7	13	33	10	27	10		4.27
February	7	10	40	23	17	3		3.08
March	3	20	27	33	10	7		3.77
April	17	13	53	7	3	7		2.31
May	10	43	37	10	0	0		1.47
June	67	17	13	3	0	0		.75
July	27	30	37	3	3	0		1.26
August	27	33	33	3	3	0		1.20
September	33	23	37	7	0	0		1.11
October	23	10	50	7	3	7		2.37
November	7	17	47	13	13	3		2.75
December	0	7	43	30	20	0		3.50

[1] Percentage figures in column headed "3.01–5 inches" based on 5 inches or less of rainfall. Percentage figures in column headed "More than 20 inches" based on 20.01 to 40 inches of rainfall.

[2] Percentage figure based on more than 40 inches of rainfall.

intense, they are usually too brief and localized to contribute significantly to the total water supply.

Hawaii's heaviest rains are brought by winter storms. Although the effects of terrain are not so obvious as in trade-wind showers, large differences in rainfall over small distances do occur, because of the topography and the path and structure of the rain clouds. Frequently, the most copious storm rains do not occur in localities that have the greatest average rainfall; nor is it uncommon during such storms for relatively dry areas to receive within a single day, or even a few hours, half or more of their mean annual rainfall. For example, downtown Honolulu has an average yearly rainfall of only 24 inches, but it has received more than 17 inches in a single day.

Intensities of 2 inches of rain an hour are not infrequent, and even the dry regions on Oahu have an average recurrence interval of only 5 years or less. In many of the farming areas, hourly intensities of 2.5 inches can be expected, and over the island as a whole, 3 inches an hour is by no means rare. Hawaii's heaviest rain was the more than 40 inches recorded at Kilauea Plantation, Kauai, in a 24-hour period in January 1956. Of this, 6 inches fell in 30 minutes and more than 11 inches in a single hour. Flash flooding is a recurrent problem and results in frequent damage to fields, crops, and other property.

Another important, but often neglected, source of water is that directly extracted from passing clouds by vegetation and by the soil in areas where an elevation of 2,500 feet or more brings them into the cloud belt. For example, at Lanaihale, the contribution of what is locally called "fog drip" to soil moisture appears to be about equal to that of rainfall.

At the opposite extreme, neither is *drought* uncommon in Hawaii, although it rarely affects more than part of even a single island at one time. Drought occurs when either the winter storms or the trade winds fail. If the winter storms fail, the leeward areas, which receive little rain from trade winds, are hardest hit. A dry winter between two normally dry summers can have very serious consequences. The failure of the trades most affects mountain and upland regions, including many of the sources of irrigation water. The probability of serious drought somewhere in Hawaii during any given 10-year period exceeds 90 percent.

TEMPERATURE.—Mean annual temperatures in Hawaii vary between about 72° and 75° F., near sea level, decrease by about 3° for each 1,000 feet of elevation, and tend to be higher in sunny dry areas. They are higher, for example, in the leeward lowlands, than in those areas that are cloudier, wetter, and more directly exposed to the trades. The average annual temperature at Mountain View, Hawaii (1,530 feet) is 67°; at Haleakala Branch Experiment Station (2,100 feet) 66°; at Kula Sanatorium (3,004 feet), 64°; at Hawaii National Park (3,971 feet) 61°; at Haleakala Ranger Station (7,030 feet) 54°; and at Mauna Loa Observatory (11,150 feet), 45°. Table 8 gives the average daily maximum and minimum temperature at six selected stations.

The average difference between daily high and low temperatures is between 10° and 20°; the higher readings occur in areas that are lower, drier, and less open to the wind. For example, on Oahu the daily range is 19° at Ewa Plantation, 13° at Kahuku, and only 8° at Makapuu Point. Lanai City, under its orographic cloud cap, is kept cooler during the day and warmer at night than Lanai Airport, which is less than 4 miles away, and the city has a mean daily range of 13° as compared with 17° at the airport.

August and September are the warmest months of the year, and January and February are the coolest. The seasonal range of temperature is only 6° to 8°, which is far below the daily range. Hence, throughout the State, the temperature varies more in the course of an average day than it does from season to season. In addition, the average nighttime temperature during most of the year is below the average temperature of the coolest months.

Almost everywhere at low elevations, the highest temperatures of the year are in the low 90's and the lowest temperatures near 50°. The warmest days are usually during Kona weather, when the trade winds, which come from cooler latitudes, fail and air stagnates over the heated islands.

As an example of the role of afternoon cloudiness in holding down the maximum temperatures, Maunaloa, at an elevation of 1,100 feet in dry West Molokai, has registered 90° or above in May through November, and 96° in September, while Lanai City only a few hundred feet higher, but shielded from the afternoon sun by an orographic cloud cap, has had no temperature higher than 88°.

WIND.—The prevailing wind throughout the year is the east-northeasterly trade. The trades vary greatly in frequency they are virtually absent for long periods at some times and blow for weeks on end at others. On the average, however, the trade winds are more persistent in summer than in winter. At Honolulu they range from a minimum of about 45 percent in January to a maximum of more than 90 percent in July, for an annual frequency of about 70 percent.

In well-exposed areas, the trades average somewhat under 15 miles an hour. They are slightly stronger in summer than in winter. A speed of 31 miles an hour is exceeded only about 2 percent of the time by the trades and 3 percent by winds from other directions.

The strongest and most damaging winds are not ordinarily the trade winds but the winds that accompany winter storms and the infrequent hurricanes. High winds are most likely between November and March and blow from almost any direction. The strongest of recent years was a gust of 103 miles an hour at Kilauea Point, Kauai, in August 1959, during Hurricane DOT, but gusts exceeding 80 miles an hour have occurred twice at Honolulu Airport since 1951 and occasionally elsewhere.

The effect of topography on the local wind is varied and profound, ranging from a complete sheltering from winds from certain directions to deflections and accelerations, that is, through passes and narrow valleys and over crests, that can transform a moderate wind into a strong and gusty one. Thus, the Hoolehua plains, the windward side of west Molokai, and the north end of Lanai are subject to severe wind erosion and occasional crop damage by strong trades funnelling between the highlands of east and west Molokai or through the channel between Molokai and Lanai. At Molokai Airport, in the central saddle, winds exceed 15 miles an hour nearly

TABLE 8.—*Average daily maximum and minimum temperatures at selected stations*

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.
KILAUEA FIELD 17, KAUAI NO. 1135												
	75. 6	74. 9	75 5	76. 4	78. 2	80. 3	80. 9	81. 9	81. 9	80. 2	78. 2	75. 7
	60. 5	59. 7	61. 3	62. 8	64. 8	67. 0	68. 1	68. 8	68. 0	66. 5	65. 6	63. 0
KANEOHE (MAUKA), OAHU NO. 781												
	77. 4	77. 2	77. 3	78. 2	79. 6	81. 5	82. 0	82. 4	82. 8	81. 9	80. 0	77. 9
	64. 9	64. 8	65. 1	66. 7	68. 2	69. 7	70. 7	71. 2	70. 3	69. 7	68. 2	66. 2
WHEELER FIELD, OAHU NO. 810												
	75. 9	76. 0	76. 1	76. 6	79. 0	81. 0	81. 7	82. 4	82. 6	81. 7	78. 8	76. 3
	60. 0	60. 0	60. 9	62. 3	63. 9	65. 7	67. 0	67. 4	66. 6	65. 6	63. 9	62. 2
KAILUA, MAUI NO. 446												
	75. 5	74. 7	75. 1	75. 7	76. 4	78. 1	79. 0	79. 4	80. 4	79. 8	77. 5	75. 0
	61. 5	61. 1	61. 5	62. 8	64. 2	65. 6	66. 5	67. 1	66. 7	65. 8	64. 6	62. 9
LAHAINA, MAUI NO. 361												
	80. 7	80. 6	80. 7	82. 6	84. 0	85. 8	87. 1	87. 4	87. 1	86. 5	84. 6	82. 3
	61. 8	61. 9	62. 0	63. 2	64. 8	66. 4	67. 6	68. 1	67. 4	66. 8	65. 3	63. 4
MAUNALOA, MOLOKAI NO. 511												
	77. 1	76. 8	77. 3	77. 6	79. 9	82. 8	83. 5	84. 6	84. 3	82. 7	79. 9	77. 6
	60. 5	60. 7	61. 2	61. 9	63. 6	65. 2	65. 8	66. 7	66. 2	65. 6	63. 8	61. 9

60 percent of the time during the entire year, and more than 75 percent of the time during the summer months.

In contrast, the Kona coast of Hawaii Island is so completely sheltered by the mountains to the east that the trades are never experienced near sea level, and local land and sea breezes constitute the prevailing winds.

CLOUD COVER.—On sunny trade wind days, all but Hawaii's tallest mountains are typically capped by cumulus clouds that overhang and shadow the slopes and coastal plains. The bases rest upon the crest. These clouds form within the moist marine air ascending the topographic barriers and dissipate again as the air descends to the lee. Hence, clouds are more frequent and extensive over windward coasts and mountains than over leeward plains and shores. At Honolulu Airport, which receives 22 inches of rainfall annually and is well to the lee of the Koolaus, skies are clear (sky cover is three-tenths or less) about 26 percent of the time, and cloudy (sky cover is eight-tenths or more) about 28 percent of the time. In contrast, Lihue Airport, on Kauai's windward coast, is clear 14 percent of the time and cloudy 40 percent.

These are seasonal and diurnal variations in cloudiness. In all months of the year, probably because of solar heating, clouds tend to be more abundant during the day than at night. Widespread persistent cloudiness is principally a phenomena of large-scale winter storms. Presumably for this reason, skies are cloudy more often in winter than in summer. At Honolulu, for example, skies are cloudy on 29 percent of January days but on only 16 percent of July days. The heaviest overcast, however, seldom lasts for more than a day or two within a few intervals of blue sky and sunshine.

RELATIVE HUMIDITY.—Relative humidity varies considerably with time and place. In general, it is higher at night than in the afternoon and higher in rainier, cooler localities than in warmer, drier ones. As the trades reach Hawaii from cooler latitudes, the humidity is by no means as high as the tropical locale and surrounding ocean might imply. At Lihue, a windward station, the humidity ranges from about 79 percent in January to 75 percent in July, and from about 82 percent at 2 a.m. to 67 percent at 2 p.m. By comparison, the values at Honolulu Airport, on the leeward coast, average 70 percent in January, 68 percent in July, 74 percent at 2 a.m., and 58 percent at 2 p.m.

HURRICANES.—Hurricanes are relatively infrequent and mild in Hawaii. Before 1950, there were no authenticated reports of hurricanes in the Hawaiian area. Four storms have occurred there since then, and a number of others have approached the State, but not closely enough to affect the weather appreciably. The most damaging hurricane to strike Hawaii—DOT, in August 1959—did

approximately $6 million in damage, largely on Kauai. About $1.5 million of this amount was damage to sugarcane.

TORNADOES.—A number of funnel clouds occur over or near the State during an average year, but most either fail to reach the ground or remain at sea as waterspouts. Only rarely does a small tornado, usually much weaker than its mainland counterpart, cause even slight damage. By far the most destructive tornado of recent years was the one that roared through the small plantation town of Kaumakani, Kauai, in the early morning of December 17, 1967. The damage to houses, sugarcane, and other crops amounted to $300,000.

HAIL.—On the average, hail falls several times a year somewhere in the State, but it is only a quarter inch or less in diameter and thus does little damage. At times, however, leafy crops have been severely battered. Hail occurs most frequently between October and April, but it has been reported in every month but July. Falls usually cover only a square mile or less; only on occasion are they more widespread.

Population

The population of the State of Hawaii in 1968 was 824,574. The island of Oahu, which makes up only 9.3 percent of the State, had a population of more than 683,796. Kauai had 24,757, Maui 41,490, Molokai 5,867, and Lanai 2,431. Hawaii and Niihau, neither of which is in the survey area, had populations of 65,941 and 292 respectively.

Transportation

Jet aircraft has reduced flight time across the Pacific from the continental United States, reduced fares, and increased visitor travel. Travel between the islands is by air. Two scheduled airlines provide jet service between major airports on each island.

Modern containerized cargo ships make regular calls to and from the mainland and the Orient. Intrastate cargo shipment is by scheduled barge service.

Modern highways link major destination areas on all the islands. Scheduled bus service is available in Honolulu.

Visitor Industry

Accommodating visitors continues to be one of Hawaii's most rapidly growing industries. Today, it exceeds sugar and pineapple as the top source of income for the State.

Farming and Ranching

The economy of Hawaii depends heavily on farming and ranching. Because of a wide range of soils and of climate, which is hot arid in some coastal areas to humid tropical and temperate in mountain regions, Hawaii produces a variety of crops. The sugar and pineapple industries have long been the dominant factors in the Hawaiian economy. Diversified crops, such as vegetables, melons, fruits, and taro, are grown mainly for local consumption. Cattle ranching is the principal livestock industry. More than half the food consumed in Hawaii is produced locally.

SUGARCANE

Sugarcane is grown on highly mechanized plantations. There are three plantations on Maui, four on Oahu, and eight on Kauai. The acreage totals about 131,000. All the sugarcane is irrigated except at higher elevations where rainfall is sufficient. The cane is processed into raw sugar at sugar mills on the plantation. The raw sugar is shipped to Crockett, Calif., where it is made into refined sugar.

The sugar workers are employed the year around. They are the highest paid of any in the sugar-producing areas.

Mechanization and technical developments have led to significant advances in land preparation, harvesting, fertilization, and weed control. The plantations average more than 11 tons of sugar per acre—the highest yield in the world.

PINEAPPLE

Pineapple is grown on all the islands in the survey area. Like sugarcane, it is grown mostly on highly mechanized plantations. There are two plantations on Molokai and Oahu, and one each on Maui, Lanai, and Kauai. There are also some independent growers on Maui and Kauai. The acreage totals about 69,000. The pineapple industry is the primary source of income on Molokai and Lanai.

Pineapple requires little water. It can be grown without irrigation in areas where rainfall is as low as 20 inches. If water is available, however, areas that receive less than 30 inches of rainfall are generally irrigated. Pineapple is an important crop on Molokai and Lanai, both of which have low rainfall and a limited supply of irrigation water. Sugarcane and other crops that require abundant water cannot be grown.

The peak harvesting season is in summer. Seasonal workers, mostly high school and university students, are hired to work in the fields and canneries.

DIVERSIFIED CROPS

Diversified crops, mainly tomatoes, cucumbers, head cabbage, lettuce, green peppers, snap beans, bananas, and papayas, are commercially produced on all islands except Lanai. Many other crops including specialty crops, such as gingerroot and taro, are grown also.

Diversified crops are grown mainly in the Kula and Kihei areas of Maui, the Waianae and Waimanalo areas of Oahu, the Hanalei, Wailua, and Hanapepe areas of Kauai, and the southern coast of Molokai. Most farms are family farms and are less than 10 acres in size. The growing season is year around, and the farms are intensively cultivated.

The largest market for the crops is on Oahu. Yet the farming areas on Oahu are decreasing because of urbanization. Farms on the neighbor islands have become increasingly important in meeting the islands' produce needs.

CATTLE

There are cattle ranches on all islands except Lanai. Most of these ranches occupy areas that are steep, stony,

or otherwise unsuitable for cultivation. The ranches range in size from less than 100 acres to more than 50,000 acres. They are operated on a part-time basis. Herefords are the most commonly raised beef cattle; others are Santa Gertrudis, Black Angus, and Charolaise.

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Glossary

Aa lava. Highly basaltic lava flows typified by a rough jagged surface.

Aggregate, soil. Many fine particles held in a single mass or cluster. Natural soil aggregates such as crumbs, blocks, or prisms, are called peds. Clods are aggregates produced by tillage or logging.

Alluvium. Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

Available water capacity. The capacity of a soil to hold water in a form available to plants. Amount of moisture held in soil between field capacity, or about one-third atmosphere of tension, and the wilting coefficient, or about 15 atmospheres of tension.

Base saturation. The degree to which material that has base-exchange properties is saturated with exchangeable cations other than hydrogen, expressed as a percentage of the cation-exchange capacity.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Colluvium. Soil material, rock fragments, or both, moved by creep, slide, or local wash and deposited at the base of steep slopes.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Slightly hard.—When dry, soil is slightly resistant to pressure but can be broken between thumb and forefinger.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Sticky.—When wet, adheres to other material and tends to stretch somewhat and pull apart, rather than to pull free.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Weakly smeary.—Under strong pressure, the soil material changes suddenly to fluid, the fingers skid, and the soil smears. After the soil smears, there is little or no evidence of free water on the fingers.

Moderately smeary.—Under moderate to strong pressure, the soil material changes suddenly to fluid, the fingers skid, and the soil smears and is slippery. After the soil smears, there is evidence of free water on the fingers.

Strongly smeary.—Under moderate pressure, the soil material changes suddenly to fluid, the fingers skid, and the soil smears and is very slippery. After the soil smears, free water is easily seen on the fingers.

Erosion. The wearing away of the land surface by wind (sandblast), running water, and other geological agents.

Flood plain. Nearly level land, consisting of stream sediments, that borders a stream and is subject to flooding unless protected artificially.

Gravel. A mass of rounded or angular fragments up to 3 inches in diameter.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major horizons:

O horizon.—The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.

A horizon.—The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and therefore is marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, and sesquioxides (iron and aluminum oxides).

B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused (1) by accumulation of clay, sesquioxides, humus, or some combination of these; (2) by prismatic or blocky structure; (3) by redder or stronger

colors than the A horizon; or (4) by some combination of these. Combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon.—The weathered rock material immediately beneath the solum. In most soils this material is presumed to be like that from which the overlying horizons formed. If the material is known to be different from that in the solum, a Roman numeral precedes the letter C.

R horizon.—Consolidated rock beneath the soil. The rock usually underlies a C horizon but may be immediately beneath an A or B horizon.

Horizon, soil diagnostic. Combinations of specific soil characteristics that indicate certain classes of soils. Those that occur at the surface are called epipedons, those below the surface, diagnostic subsurface horizons.

Albic horizon.—A residual concentration of quartz and other primary minerals of gray to white colors.

Argillic horizon.—An accumulation of illuvial silicate clay. If the layer has an appreciable amount of exchangeable sodium and prismatic or columnar structure, it is called a natric horizon.

Calcic horizon.—An accumulation of appreciable amounts of calcium carbonate.

Cambic horizon.—A layer in which changes have been sufficient (1) to give rise to structure, (2) to liberate free iron oxide, (3) to form silicate clay minerals, (4) to obliterate most evidence of original rock structure, or (5) some combination of these. Illuviation of iron, humus, or clay is not sufficient to qualify horizon as argillic or spodic.

Histic epipedon.—A thin, less than 30 centimeters, organic layer (peat or muck) that is normally saturated with water.

Mollic epipedon.—A thick, dark-colored surface layer that is much like the surface layer of soils that formed under grass. This layer may have moderate to strong structure, a base saturation of 50 percent or more, and calcium as the dominant metallic cation.

Natric horizon.—A special kind of argillic horizon that has prismatic or columnar structure, generally columnar, and 15 percent saturation with sodium. If the C horizon also has more than 15 percent sodium, the natric horizon must have more magnesium plus sodium than calcium plus hydrogen.

Ochric epipedon.—A surface horizon that contains some organic matter but is too light colored or too thin to meet the requirements of other kinds of epipedons.

Oxic horizon.—A residual concentration of lattice clays and free sesquioxides that has very low cation exchange capacity.

Petrocalcic horizon.—A continuous indurated calcic horizon cemented with carbonates of calcium and in places with magnesium.

Spodic horizon.—An accumulation of illuvial humus and aluminum or iron in amorphous forms.

Duripan.—A horizon indurated with silicon dioxide, generally opal, to the extent that dry fragments will not slake in water.

Miscellaneous land type. A mapping unit for areas of land that have little or no natural soil; or that are too nearly inaccessible for orderly examination; or that occur where, for other reasons, it is not feasible to classify the soil.

Mottled. Irregularly marked with spots of different colors that vary in number and size. Mottling in soils usually indicates poor aeration and lack of drainage. Descriptive terms are as follows: Abundance—*few*, *common*, and *many;* size—*fine*, *medium*, and *coarse;* and contrast—*faint*, *distinct*, and *prominent*. The size measurements are these: *fine*, less than 5 millimeters (about 0.2 inch) in diameter along the greatest dimension; *medium*, ranging from 5 millimeters to 15 millimeters (about 0.2 to 0.6 inch) in diameter along the greatest dimension; and *coarse*, more than 15 millimeters (about 0.6 inch) in diameter along the greatest dimension.

Natural soil drainage. Refers to the conditions of frequency and duration of periods of saturation of partial saturation that existed during the development of the soil, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven different classes of natural soil drainage are recognized.

Excessively drained soils are commonly very porous and rapidly permeable and have a low available water capacity.

Somewhat excessively drained soils are also very permeable and are free from mottling throughout their profile.

Well-drained soils are nearly free from mottling and are commonly of intermediate texture.

Moderately well drained soils commonly have a slowly permeable layer in or immediately beneath the solum. They have uniform color in the A and upper B horizons and have mottling in the lower B and the C horizons.

Imperfectly or somewhat poorly drained soils are wet for significant periods but not all the time, and Podzolic soils commonly have mottlings below a depth of 6 to 16 inches, in the lower A horizon and in the B and C horizons.

Poorly drained soils are wet for long periods and are light gray and generally mottled from the surface downward, although mottling may be absent or nearly so in some soils.

Very poorly drained soils are wet nearly all the time. They have a dark-gray or black surface layer and are gray or light gray, with or without mottling, in the deeper parts of the profile.

Pahoehoe lava. Massive, impermeable basaltic lava flows typified by a smooth, billowy, or ropy surface.

Parent material (soil). The horizon of weathered rock or partly weathered soil material from which soil has formed; horizon C in the soil profile.

Permeability, soil. The capacity of a soil horizon to transmit air or water. Terms used to describe permeability are as follows: *very slow, slow, moderately slow, moderate, moderately rapid, rapid,* and *very rapid.*

Plinthite. The sesquioxide-rich, humus-poor, highly weathered mixture of clay with quartz and other dilutents that commonly shows as red mottles, usually in platy, polygonal, or reticulate patterns. Plinthite changes irreversibly to hardpan or to irregular aggregates on repeated wetting and drying, or it is the hardened relicts of the soft, red mottles. It is a form of the material that has been called laterite.

Profile, soil. A vertical section of the soil through all its horizons and extending into the parent material.

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction because it is neither acid nor alkaline. An acid, or "sour," soil is one that gives an acid reaction; an alkaline soil is one that is alkaline in reaction. In words, the degrees of acidity or alkalinity are expressed thus:

	pH		*pH*
Extremely acid	Below 4.5	Mildly alkaline	7.4 to 7.8
Very strongly acid	4.5 to 5.0	Moderately alkaline	7.9 to 8.4
Strongly acid	5.1 to 5.5	Strongly alkaline	8.5 to 9.0
Medium acid	5.6 to 6.0	Very strongly alkaline	9.1 and higher
Slightly acid	6.1 to 6.5		
Neutral	6.6 to 7.3		

Saline soil. A soil that contains soluble salts in amounts that impair growth of plants but that does not contain excess exchangeable sodium.

Sand. Individual rock or mineral fragments in soils having diameters ranging from 0.05 millimeter to 2.0 millimeters. Most sand grains consist of quartz, but they may be any mineral composition. The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay.

Saprolite. Thoroughly decomposed, earthy, untransported rock.

Series, soil. A group of soils developed from a particular type of parent material and having genetic horizons that, except for texture of the surface layer, are similar in differentiating characteristics and in arrangement in the profile.

Silt. Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay.

Soil. A natural, three-dimensional body on the earth's surface that supports plants and that has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

Solum. The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum in mature soil includes the A and B horizons. Generally, the characteristics of the material in these horizons are unlike

those of the underlying material. The living roots and other plant and animal life characteristic of the soil are largely confined to the solum.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are (1) *single grain* (each grain by itself, as in dune sand) or (2) *massive* (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Substratum. Technically the part of the soil below the solum.

Surface soil. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness. The plowed layer.

Terrace (geological). An old alluvial plain, ordinarily flat or undulating, bordering a river, lake, or the sea. Stream terraces are frequently called second bottoms, as contrasted to flood plains, and are seldom subject to overflow. Marine terraces were deposited by the sea and are generally wide.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay*, and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Water table. The highest part of the soil or underlying rock material that is wholly saturated with water. In some places an upper, or perched, water table may be separated from a lower one by a dry zone.

GUIDE TO MAPPING UNITS

For a full description of a mapping unit, read both the description of the mapping unit and that of the soil series to which the mapping unit belongs. An explanation of capability classification begins on page 153. Other information is given in tables as follows:

Acreage and extent, table 1, page 15.

Use of the soils in engineering, table 2, page 156, table 3, page 168, table 4, page 202.

HIGH- AND MEDIUM- INTENSITY SURVEY

Map symbol	Mapping unit	Described on page	Capability classification: Irrigated Symbol	Capability classification: Nonirrigated Symbol	Sugarcane group No.	Sugarcane group Page	Pineapple group No.	Pineapple group Page	Pasture group No.	Pasture group Page	Woodland group No.	Woodland group Page
AaB	Alae sandy loam, 3 to 7 percent slopes	26	IVs	VIs	1	136	--	---	1	143	--	---
AcA	Alae cobbly sandy loam, 0 to 3 percent slopes	14	IVs	VIs	1	136	--	---	1	143	--	---
AcB	Alae cobbly sandy loam, 3 to 7 percent slopes	26	IVs	VIs	1	136	--	---	1	143	--	---
AeB	Alaeloa silty clay, 3 to 7 percent slopes	26	IIe	IIe	--	---	5	140	6	145	5	150
AeC	Alaeloa silty clay, 7 to 15 percent slopes	26	IIIe	IIIe	--	---	6	140	6	145	5	150
AeE	Alaeloa silty clay, 15 to 35 percent slopes	26	---	VIe	--	---	6	140	6	145	5	150
EaA	Ewa silty clay loam, 0 to 3 percent slopes	30	I	IVc	1	136	1	137	2	144	--	---
EaB	Ewa silty clay loam, 3 to 6 percent slopes	29	IIe	IVc	1	136	2	138	2	144	--	---
EaC	Ewa silty clay loam, 6 to 12 percent slopes	30	IIIe	IVe	1	136	3	139	2	144	--	---
EcA	Ewa cobbly silty clay loam, 0 to 3 percent slopes	30	IIs	IVs	1	136	--	---	2	144	--	---
EcB	Ewa cobbly silty clay loam, 3 to 7 percent slopes	30	IIe	IVs	1	136	--	---	2	144	--	---
EmA	Ewa silty clay loam, moderately shallow, 0 to 2 percent slopes	30	IIs	IVs	1	136	1	137	2	144	--	---
EmB	Ewa silty clay loam, moderately shallow, 2 to 6 percent slopes	30	IIe	IVs	1	136	2	138	2	144	--	---
EsA	Ewa silty clay, 0 to 3 percent slopes	30	I	IVc	1	136	1	137	2	144	--	---
EsB	Ewa silty clay, 3 to 7 percent slopes	30	IIe	IVc	1	136	2	138	2	144	--	---
EtB	Ewa cobbly silty clay, 3 to 7 percent slopes	30	IIe	IVs	1	136	2	138	2	144	--	---
EwA	Ewa stony silty clay, 0 to 2 percent slopes	30	IIs	IVs	1	136	--	---	2	144	--	---
EwB	Ewa stony silty clay, 2 to 6 percent slopes	30	IIe	IVs	1	136	--	---	2	144	--	---
EwC	Ewa stony silty clay, 6 to 12 percent slopes	31	IIIe	IVe	1	136	--	---	2	144	--	---
Fd	Fill land	31	----	---	--	---	--	---	--	---	--	---
HaB	Haiku silty clay, 3 to 7 percent slopes	32	IIe	IIe	--	---	5	140	8	145	7	151
HaC	Haiku silty clay, 7 to 15 percent slopes	32	IIIe	IIIe	--	---	6	140	8	145	7	151
HbB	Haiku clay, 3 to 7 percent slopes	32	IIe	IIe	--	---	5	140	8	145	7	151
HbC	Haiku clay, 7 to 15 percent slopes	32	IIIe	IIIe	--	---	6	140	8	145	7	151

Map symbol	Mapping unit	Described on page	Capability classification: Irrigated Symbol	Capability classification: Nonirrigated Symbol	Sugarcane group No.	Sugarcane group Page	Pineapple group No.	Pineapple group Page	Pasture group No.	Pasture group Page	Woodland group No.	Woodland group Page
HcB	Haleiwa silty clay loam, 0 to 10 percent slopes--------------------	34	IIIe	IIIe	1	136	--	---	3	144	1	149
HdC	Haleiwa very stony silty clay loam, 0 to 15 percent slopes-----------	34	VIs	VIs	--	---	--	---	3	144	1	149
HeA	Haleiwa silty clay, 0 to 2 percent slopes---------------------------	33	IIe	IIIc	1	136	--	---	3	144	1	149
HeB	Haleiwa silty clay, 2 to 6 percent slopes---------------------------	34	IIe	IIIc	1	136	--	---	3	144	1	149
HfB	Halii gravelly silty clay, 3 to 8 percent slopes--------------------	34	---	IVs	2	136	7	141	10	146	9	151
HfC	Halii gravelly silty clay, 8 to 15 percent slopes--------------------	35	---	IVe	2	136	8	141	10	146	9	151
HfD2	Halii gravelly silty clay, 15 to 25 percent slopes, eroded---------	35	---	IVe	2	136	--	---	10	146	9	151
HfE2	Halii gravelly silty clay, 25 to 40 percent slopes, eroded---------	35	---	VIe	--	---	--	---	10	146	9	151
HgB	Haliimaile silty clay loam, 3 to 7 percent slopes--------------------	36	IIe	IIe	1	136	5	140	3	144	1	149
HgC	Haliimaile silty clay loam, 7 to 15 percent slopes-------------------	36	IIIe	IIIe	1	136	6	140	3	144	1	149
HhB	Haliimaile silty clay, 3 to 7 percent slopes----------------------	35	IIe	IIe	1	136	5	140	3	144	1	149
HhC	Haliimaile silty clay, 7 to 15 percent slopes-------------------	36	IIIe	IIIe	1	136	6	140	3	144	1	149
HkC2	Haliimaile gravelly silty clay, 7 to 15 percent slopes, eroded------	36	IVe	IVe	1	136	6	140	3	144	1	149
HlB	Hamakuapoko silty clay, 3 to 7 percent slopes----------------------	36	IIe	IIe	--	---	5	140	6	145	5	150
HlC	Hamakuapoko silty clay, 7 to 15 percent slopes-------------------	37	IIIe	IIIe	--	---	6	140	6	145	5	150
HlC2	Hamakuapoko silty clay, 7 to 15 percent slopes-------------------	37	IVe	IVe	--	---	6	140	6	145	5	150
HmA	Hanalei silty clay loam, 0 to 2 percent slopes-------------------	38	IIw	IIw	3	137	--	---	7	145	4	149
HnA	Hanalei silty clay, 0 to 2 percent slopes-------------------------	38	IIw	IIw	3	137	--	---	7	145	4	149
HnB	Hanalei silty clay, 2 to 6 percent slopes-------------------------	38	IIw	IIw	3	137	--	---	7	145	4	149
HoB	Hanalei stony silty clay, 2 to 6 percent slopes-------------------	38	IIw	IIw	3	137	--	---	7	145	4	149
HpA	Hanalei peaty silty clay loam, 0 to 2 percent slopes---------------	38	IVw	IVw	3	137	--	---	7	145	4	149
HrB	Hanalei silty clay, deep water table, 0 to 6 percent slopes------	38	IIw	IIw	3	137	--	---	7	145	4	149
HsB	Hanamaulu silty clay, 3 to 8 percent slopes-----------------------	39	IIe	IIe	2	136	--	---	8	145	7	151
HsC	Hanamaulu silty clay, 8 to 15 percent slopes-------------------	39	IIIe	IIIe	2	136	--	---	8	145	7	151
HsD	Hanamaulu silty clay, 15 to 25 percent slopes-------------------	39	IVe	IVe	2	136	--	---	8	145	7	151
HsE	Hanamaulu silty clay, 25 to 40 percent slopes-------------------	39	---	VIe	--	---	--	---	8	145	7	151
HtE	Hanamaulu stony silty clay, 10 to 35 percent slopes----------------	39	---	VIe	--	---	--	---	8	145	7	151
HuE	Hanamaulu bouldery silty clay, 10 to 35 percent slopes----------	39	---	VIe	--	---	--	---	8	145	7	151

Map symbol	Mapping unit	Described on page	Capability classification: Irrigated Symbol	Capability classification: Nonirrigated Symbol	Sugarcane group No.	Sugarcane group Page	Pineapple group No.	Pineapple group Page	Pasture group No.	Pasture group Page	Woodland group No.	Woodland group Page
KaeB	Kaena stony clay, 2 to 6 percent slopes	50	IIIw	IVw	4	137	--	---	7	145	4	149
KaeC	Kaena stony clay, 6 to 12 percent slopes	49	IIIw	IVw	4	137	--	---	7	145	4	149
KaeD	Kaena stony clay, 12 to 20 percent slopes	50	IVw	VIw	4	137	--	---	7	145	4	149
KanE	Kaena very stony clay, 10 to 35 percent slopes	50	---	VIs	--	---	--	---	7	145	4	149
KavB	Kaena clay, brown variant, 1 to 6 percent slopes	50	IIIw	IVw	3	137	--	---	7	145	4	149
KavC	Kaena clay, brown variant, 6 to 12 percent slopes	50	IIIw	IVw	3	137	--	---	7	145	4	149
KbB	Kahana silty clay, 3 to 7 percent slopes	51	IIe	IIe	--	---	5	140	3	144	1	149
KbC	Kahana silty clay, 7 to 15 percent slopes	50	IIIe	IIIe	--	---	6	140	3	144	1	149
KbD	Kahana silty clay, 15 to 25 percent slopes	51	IVe	IVe	--	---	6	140	3	144	1	149
KcB	Kalae silty clay, 2 to 7 percent slopes	54	IIe	IIIc	--	---	5	140	6	145	5	150
KcC	Kalae silty clay, 7 to 15 percent slopes	55	IIIe	IIIe	--	---	6	140	6	145	5	150
KcC3	Kalae silty clay, 5 to 15 percent slopes, severely eroded	55	IVe	IVe	--	---	6	140	6	145	5	150
KcD3	Kalae silty clay, 15 to 25 percent slopes, severely eroded	55	VIe	VIe	--	---	--	---	6	145	5	150
KcE3	Kalae silty clay, 25 to 40 percent slopes, severely eroded	55	---	VIe	--	---	--	---	6	145	5	150
KdD	Kalapa silty clay, 8 to 20 percent slopes	56	IVe	IVe	2	136	--	---	8	145	7	151
KdE	Kalapa silty clay, 20 to 40 percent slopes	56	---	VIe	--	---	--	---	8	145	7	151
KdF	Kalapa silty clay, 40 to 70 percent slopes	55	---	VIIe	--	---	--	---	8	145	14	152
Ke	Kalihi clay	57	IIIw	IVw	3	137	--	---	7	145	4	149
Kf	Kaloko clay loam	58	IIIw	Vw	3	137	--	---	7	145	--	---
Kfa	Kaloko clay	58	IIIw	Vw	3	137	--	---	7	145	--	---
Kfb	Kaloko clay, noncalcareous variant	58	IIIw	Vw	3	137	--	---	7	145	--	---
KgB	Kaneohe silty clay, 3 to 8 percent slopes	59	---	IIe	--	---	--	---	8	145	7	151
KgC	Kaneohe silty clay, 8 to 15 percent slopes	60	---	IIIe	--	---	--	---	8	145	7	151
KhB	Kanepuu silty clay, 3 to 7 percent slopes	60	IIe	IIIc	--	---	--	---	3	144	--	---
KhB2	Kanepuu silty clay, 3 to 7 percent slopes, eroded	61	IIe	IIIc	--	---	--	---	3	144	--	---
KhC	Kanepuu silty clay, 7 to 15 percent slopes	61	IIIe	IIIe	--	---	--	---	3	144	--	---
KhC2	Kanepuu silty clay, 7 to 15 percent slopes, eroded	61	IIIe	IVe	--	---	--	---	3	144	--	---
KkB	Kapaa silty clay, 3 to 8 percent slopes	61	---	IIIs	2	136	7	141	10	146	9	151
KkC	Kapaa silty clay, 8 to 15 percent slopes	62	---	IIIe	2	136	8	141	10	146	9	151

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KkD	Kapaa silty clay, 15 to 25 percent slopes	62	---	IVe	2	136	8	141	10	146	9	151
KkE	Kapaa silty clay, 25 to 40 percent slopes	62	---	VIe	--	---	--	---	10	146	9	151
KlA	Kawaihapai clay loam, 0 to 2 percent slopes	64	I	IIc	1	136	--	---	3	144	1	149
KlB	Kawaihapai clay loam, 2 to 6 percent slopes	64	IIe	IIe	1	136	--	---	3	144	1	149
KlC	Kawaihapai clay loam, 6 to 15 percent slopes	64	IIIe	IIIe	1	136	--	---	3	144	1	149
KlaA	Kawaihapai stony clay loam, 0 to 2 percent slopes	64	IIs	IIs	1	136	--	---	3	144	1	149
KlaB	Kawaihapai stony clay loam, 2 to 6 percent slopes	64	IIe	IIe	1	136	--	---	3	144	1	149
KlbC	Kawaihapai very stony clay loam, 0 to 15 percent slopes	64	---	VIs	--	---	--	---	3	144	1	149
KlcB	Kawaihapai silty clay loam, 2 to 7 percent slopes	64	IIe	IIe	1	136	--	---	3	144	1	149
KmA	Keaau clay, 0 to 2 percent slopes	65	IIIw	Vw	3	137	--	---	7	145	4	149
KmaB	Keaau stony clay, 2 to 6 percent slopes	65	IIIw	Vw	3	137	--	---	7	145	4	149
KmbA	Keaau clay, saline, 0 to 2 percent slopes	65	---	VIw	--	---	--	---	7	145	4	149
KnB	Keahua silty clay loam, 3 to 7 percent slopes	65	IIe	IVc	1	136	2	138	2	144	--	---
KnC	Keahua silty clay loam, 7 to 15 percent slopes	66	IIIe	IVe	1	136	3	139	2	144	--	---
KnaB	Keahua cobbly silty clay loam, 3 to 7 percent slopes	66	IIe	IVs	1	136	--	---	2	144	--	---
KnaC	Keahua cobbly silty clay loam, 7 to 15 percent slopes	66	IIIe	IVe	1	136	--	---	2	144	--	---
KnaD	Keahua cobbly silty clay loam, 15 to 25 percent slopes	66	IVe	IVe	1	136	--	---	2	144	--	---
KnbD	Keahua very stony silty clay loam, 7 to 25 percent slopes	66	---	VIs	--	---	--	---	2	144	--	---
KncC	Keahua silty clay, 7 to 15 percent slopes	66	IIIe	IVe	1	136	3	139	2	144	--	---
KnhC	Keahua cobbly silty clay, 7 to 15 percent slopes	66	IIIe	IVe	1	136	--	---	2	144	--	---
KnsC	Keahua stony silty clay, 7 to 15 percent slopes	67	IIIe	IVe	1	136	--	---	2	144	--	---
KoA	Kekaha silty clay, 0 to 2 percent slopes	68	I	IVc	1	136	--	---	2	144	4	149
KoB	Kekaha silty clay, 2 to 6 percent slopes	69	IIe	IVc	1	136	--	---	2	144	4	149
KobA	Kekaha clay, 0 to 2 percent slopes	69	I	IVc	1	136	--	---	2	144	4	149
KpB	Kemoo silty clay, 2 to 6 percent slopes	70	---	IIe	1	136	5	140	5	145	5	150
KpC	Kemoo silty clay, 6 to 12 percent slopes	70	---	IIIe	1	136	6	140	5	145	5	150
KpD	Kemoo silty clay, 12 to 20 percent slopes	69	---	IVe	1	136	6	140	5	145	5	150
KpE	Kemoo silty clay, 20 to 35 percent slopes	70	---	VIe	--	---	--	---	5	145	5	150

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KpF	Kemoo silty clay, 35 to 70 percent slopes	70	---	VIIe	--	---	--	---	5	145	15	152
KrB	Koele silty clay loam, 3 to 7 percent slopes	70	IIe	IIIc	--	---	2	138	3	144	--	---
KrC	Koele silty clay loam, 7 to 15 percent slopes	71	IIIe	IIIe	--	---	3	139	3	144	--	---
KrD	Koele silty clay loam, 15 to 25 percent slopes	71	IVe	IVe	--	---	3	139	3	144	--	---
KsB	Koko silt loam, 2 to 6 percent slopes	72	IIe	VIc	--	---	--	---	2	144	--	---
KsC	Koko silt loam, 6 to 12 percent slopes	73	IIIe	VIe	--	---	--	---	2	144	--	---
KsD	Koko silt loam, 12 to 25 percent slopes	73	IVe	VIe	--	---	--	---	2	144	--	---
KtC	Kokokahi clay, 6 to 12 percent slopes	73	---	VIe	--	---	--	---	3	144	--	---
KuB	Kolekole silty clay loam, 1 to 6 percent slopes	73	IIe	IIIe	1	136	5	140	6	145	6	150
KuC	Kolekole silty clay loam, 6 to 12 percent slopes	74	IIIe	IIIe	1	136	6	140	6	145	6	150
KuD	Kolekole silty clay loam, 12 to 25 percent slopes	74	IVe	IVe	1	136	6	140	6	145	6	150
KvB	Koloa stony silty clay, 3 to 8 percent slopes	74	IIe	IVe	1	136	--	---	5	145	5	150
KvC	Koloa stony silty clay, 8 to 15 percent slopes	75	IIIe	IVe	1	136	--	---	5	145	5	150
KvD	Koloa stony silty clay, 15 to 25 percent slopes	75	IVe	IVe	1	136	--	---	5	145	5	150
Kw	Kolokolo clay loam	75	IIw	IIw	--	---	--	---	8	145	7	151
KxC	Kula loam, 4 to 12 percent slopes	77	IIIe	IIIe	--	---	--	---	4	144	2	149
KxD	Kula loam, 12 to 20 percent slopes	77	IVe	IVe	--	---	--	---	4	144	2	149
KxaD	Kula cobbly loam, 12 to 20 percent slopes	76	IVe	IVe	--	---	--	---	4	144	2	149
KxbE	Kula very rocky loam, 12 to 40 percent slopes	77	---	VIs	--	---	--	---	4	144	2	149
KyA	Kunia silty clay, 0 to 3 percent slopes	77	I	IIIc	1	136	1	137	3	144	1	149
KyB	Kunia silty clay, 3 to 8 percent slopes	78	IIe	IIIc	1	136	2	138	3	144	1	149
KyC	Kunia silty clay, 8 to 15 percent slopes	78	IIIe	IIIe	1	136	3	139	3	144	1	149
LaA	Lahaina silty clay, 0 to 3 percent slopes	79	I	IIIc	1	136	1	137	3	144	1	149
LaB	Lahaina silty clay, 3 to 7 percent slopes	78	IIe	IIIc	1	136	2	138	3	144	1	149
LaB3	Lahaina silty clay, 3 to 7 percent slopes, severely eroded	79	IIIe	IVe	1	136	2	138	3	144	1	149
LaC	Lahaina silty clay, 7 to 15 percent slopes	79	IIIe	IIIe	1	136	3	139	3	144	1	149
LaC3	Lahaina silty clay, 7 to 15 percent slopes, severely eroded	79	IVe	IVe	1	136	3	139	3	144	1	149
LaD	Lahaina silty clay, 15 to 25 percent slopes	79	IVe	IVe	1	136	3	139	3	144	1	149
LaD3	Lahaina silty clay, 15 to 25 percent slopes, severely eroded	79	VIe	VIe	--	---	--	---	3	144	1	149

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LaE3	Lahaina silty clay, 25 to 40 percent slopes, severely eroded	79	VIe	VIe	--	---	--	---	3	144	1	149
LcB	Lawai silty clay, 0 to 8 percent slopes	81	---	IIIw	2	136	--	---	8	145	7	151
LcC	Lawai silty clay, 8 to 15 percent slopes	81	---	IIIe	2	136	--	---	8	145	7	151
LcD	Lawai silty clay, 15 to 25 percent slopes	81	---	IVe	2	136	--	---	8	145	7	151
LeB	Leilehua silty clay, 2 to 6 percent slopes	81	IIe	IIe	2	136	5	140	8	145	7	151
LeC	Leilehua silty clay, 6 to 12 percent slopes	82	IIIe	IIIe	2	136	6	140	8	145	7	151
LhB	Lihue silty clay, 0 to 8 percent slopes	82	IIe	IIe	1	136	5	140	5	145	5	150
LhC	Lihue silty clay, 8 to 15 percent slopes	83	IIIe	IIIe	1	136	6	140	5	145	5	150
LhD	Lihue silty clay, 15 to 25 percent slopes	83	IVe	IVe	1	136	6	140	5	145	5	150
LhE2	Lihue silty clay, 25 to 40 percent slopes, eroded	83	---	VIe	--	---	--	---	5	145	5	150
LlB	Lihue gravelly silty clay, 0 to 8 percent slopes	83	IIe	IIe	1	136	5	140	5	145	5	150
LlC	Lihue gravelly silty clay, 8 to 15 percent slopes	83	IIIe	IIIe	1	136	6	140	5	145	5	150
LoB	Lolekaa silty clay, 3 to 8 percent slopes	83	---	IIe	--	---	--	---	8	145	7	151
LoC	Lolekaa silty clay, 8 to 15 percent slopes	84	---	IIIe	--	---	--	---	8	145	7	151
LoD	Lolekaa silty clay, 15 to 25 percent slopes	84	---	IVe	--	---	--	---	8	145	7	151
LoE	Lolekaa silty clay, 25 to 40 percent slopes	84	---	VIe	--	---	--	---	8	145	7	151
LoF	Lolekaa silty clay, 40 to 70 percent slopes	84	---	VIIe	--	---	--	---	8	145	14	152
LuA	Lualualei clay, 0 to 2 percent slopes	84	IIIs	VIs	4	137	--	---	2	144	4	149
LuB	Lualualei clay, 2 to 6 percent slopes	85	IIIe	VIs	4	137	--	---	2	144	4	149
LvA	Lualualei stony clay, 0 to 2 percent slopes	85	IIIs	VIs	4	137	--	---	2	144	4	149
LvB	Lualualei stony clay, 2 to 6 percent slopes	85	IIIe	VIs	4	137	--	---	2	144	4	149
MaC	Mahana silt loam, 6 to 12 percent slopes	85	IIIe	IVe	1	136	6	140	6	145	5	150
MaD	Mahana silt loam, 12 to 20 percent slopes	86	IVe	IVe	1	136	6	140	6	145	5	150
MaD3	Mahana silt loam, 12 to 20 percent slopes, severely eroded	86	IVe	VIe	1	136	6	140	6	145	5	150
MaE	Mahana silt loam, 20 to 35 percent slopes	86	---	VIe	--	---	--	---	6	145	5	150
MaE3	Mahana silt loam, 20 to 35 percent slopes, severely eroded	86	---	VIe	--	---	--	---	6	145	5	150
McC2	Mahana silty clay loam, 6 to 12 percent slopes, eroded	86	IIIe	IVe	1	136	6	140	6	145	5	150
McD2	Mahana silty clay loam, 12 to 20 percent slopes, eroded	86	IVe	IVe	1	136	6	140	6	145	5	150

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McE2	Mahana silty clay loam, 20 to 35 percent slopes, eroded	86	---	VIe	--	---	--	---	6	145	5	150
MdB	Makalapa clay, 2 to 6 percent slopes	87	---	IIIs	4	137	--	---	3	144	--	---
MdC	Makalapa clay, 6 to 12 percent slopes	88	---	IVe	4	137	--	---	3	144	--	---
MdD	Makalapa clay, 12 to 20 percent slopes	88	---	IVe	4	137	--	---	3	144	--	---
MeB	Makapili silty clay, 0 to 8 percent slopes	88	IIe	IIe	--	---	--	---	10	146	9	151
MeC	Makapili silty clay, 8 to 15 percent slopes	89	IIIe	IIIe	--	---	--	---	10	146	9	151
MeD	Makapili silty clay, 15 to 25 percent slopes	89	IVe	IVe	--	---	--	---	10	146	9	151
MeE	Makapili silty clay, 25 to 40 percent slopes	89	---	VIe	--	---	--	---	10	146	9	151
MfB	Makawao silty clay, 3 to 7 percent slopes	89	---	IIe	--	---	5	140	8	145	7	151
MfC	Makawao silty clay, 7 to 15 percent slopes	90	---	IIIe	--	---	6	140	8	145	7	151
MgB	Makaweli silty clay loam, 0 to 6 percent slopes	90	IIe	IVc	1	136	--	---	2	144	--	---
MgC	Makaweli silty clay loam, 6 to 12 percent slopes	90	IIIe	IVe	1	136	--	---	2	144	--	---
MgD	Makaweli silty clay loam, 12 to 20 percent slopes	90	IVe	IVe	1	136	--	---	2	144	--	---
MgE2	Makaweli silty clay loam, 20 to 35 percent slopes, eroded	90	---	VIe	--	---	--	---	2	144	--	---
MhB	Makaweli stony silty clay loam, 0 to 6 percent slopes	90	IIe	IVs	1	136	--	---	2	144	--	---
MhC	Makaweli stony silty clay loam, 6 to 12 percent slopes	91	IIIe	IVe	1	136	--	---	2	144	--	---
MhD	Makaweli stony silty clay loam, 12 to 20 percent slopes	91	IVe	IVe	1	136	--	---	2	144	--	---
MhE	Makaweli stony silty clay loam, 20 to 35 percent slopes	91	---	VIe	--	---	--	---	2	144	--	---
MkA	Makiki clay loam, 0 to 2 percent slopes	91	---	IIIc	--	---	--	---	--	---	--	---
MlA	Makiki stony clay loam, 0 to 3 percent slopes	92	---	IIIs	--	---	--	---	--	---	--	---
MmA	Mala silty clay, 0 to 3 percent slopes	92	I	VIc	--	---	--	---	1	143	--	---
MmB	Mala silty clay, 3 to 7 percent slopes	93	IIe	VIc	--	---	--	---	1	143	--	---
MnC	Mamala stony silty clay loam, 0 to 12 percent slopes	93	IIIs	VIs	1	136	--	---	2	144	--	---
MoB	Manana silty clay loam, 2 to 6 percent slopes	94	IIe	IIIe	1	136	5	140	6	145	6	150
MoC	Manana silty clay loam, 6 to 12 percent slopes	94	IIIe	IVe	1	136	6	140	6	145	6	150
MoD2	Manana silty clay loam, 12 to 25 percent slopes, eroded	94	VIe	VIe	1	136	--	---	6	145	6	150
MpB	Manana silty clay, 3 to 8 percent slopes	94	IIe	IIe	1	136	5	140	6	145	6	150
MpC	Manana silty clay, 8 to 15 percent slopes	95	IIIe	IIIe	1	136	6	140	6	145	6	150

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MpD	Manana silty clay, 15 to 25 percent slopes	95	IVe	IVe	1	136	6	140	6	145	6	150
MpD2	Manana silty clay, 12 to 25 percent slopes, eroded	95	VIe	VIe	1	136	--	---	6	145	6	150
MpE	Manana silty clay, 25 to 40 percent slopes	95	---	VIe	--	---	--	---	6	145	6	150
Mr	Mokuleia fine sandy loam	95	IIIs	IVs	1	136	--	---	3	144	--	---
Ms	Mokuleia loam	96	IIs	VIs	1	136	--	---	3	144	--	---
Mt	Mokuleia clay loam	95	IIs	VIs	1	136	--	---	3	144	--	---
Mta	Mokuleia clay loam, poorly drained variant	96	IIIw	IIIw	3	137	--	---	3	144	--	---
Mtb	Mokuleia clay	95	IIIs	VIs	1	136	--	---	3	144	--	---
MuA	Molokai silty clay loam, 0 to 3 percent slopes	96	I	IVc	1	136	1	137	2	144	--	---
MuB	Molokai silty clay loam, 3 to 7 percent slopes	96	IIe	IVc	1	136	2	138	2	144	--	---
MuB3	Molokai silty clay loam, 3 to 7 percent slopes, severely eroded	97	IIIe	IVe	1	136	2	138	2	144	--	---
MuC	Molokai silty clay loam, 7 to 15 percent slopes	97	IIIe	IVe	1	136	3	139	2	144	--	---
MuC3	Molokai silty clay loam, 7 to 15 percent slopes, severely eroded	97	IVe	VIe	--	---	3	139	2	144	--	---
MuD	Molokai silty clay loam, 15 to 25 percent slopes	97	IVe	IVe	1	136	3	139	2	144	--	---
MvD3	Molokai silty clay loam, shallow variant, 15 to 25 percent slopes, severely eroded	97	VIe	VIe	--	---	--	---	2	144	--	---
NcC	Niu silty clay loam, 6 to 12 percent slopes	98	IIIe	IIIe	1	136	--	---	3	144	1	149
NcD	Niu silty clay loam, 12 to 20 percent slopes	98	IVe	IVe	1	136	--	---	3	144	1	149
NcD2	Niu silty clay loam, 6 to 20 percent slopes, eroded	98	---	IVe	1	136	--	---	3	144	1	149
NcE2	Niu silty clay loam, 20 to 35 percent slopes, eroded	98	---	VIe	--	---	--	---	3	144	1	149
Nh	Nohili clay	99	IIIw	Vw	3	137	--	---	7	145	--	---
NnC	Nonopahu clay, 2 to 10 percent slopes	100	IIIe	VIe	4	137	--	---	2	144	--	---
NoC	Nonopahu stony clay, 2 to 12 percent slopes	101	IIIe	VIe	4	137	--	---	2	144	--	---
OlD	Oli loam, 12 to 20 percent slopes	103	IVe	IVe	--	---	--	---	6	145	5	150
PaC	Paaloa silty clay, 3 to 12 percent slopes	106	---	IIIe	2	136	--	---	8	145	7	151
PbC	Paaloa clay, 2 to 12 percent slopes	106	---	IIIe	2	136	--	---	8	145	7	151
PcB	Paia silty clay, 3 to 7 percent slopes	107	IIe	IIIc	1	136	--	---	3	144	--	---
PcC	Paia silty clay, 7 to 15 percent slopes	107	IIIe	IIIe	1	136	--	---	3	144	--	---
PcC2	Paia silty clay, 7 to 15 percent slopes, eroded	107	IVe	IVe	1	136	--	---	3	144	--	---
PdA	Pakala clay loam, 0 to 2 percent slopes	107	I	IVc	1	136	--	---	2	144	4	149

Map symbol	Mapping unit	Described on page	Capability classification: Irrigated	Capability classification: Nonirrigated	Sugarcane group		Pineapple group		Pasture group		Woodland group	
			Symbol	Symbol	No.	Page	No.	Page	No.	Page	No.	Page
PdC	Pakala clay loam, 2 to 10 percent slopes--------------------	108	IIe	IVe	1	136	--	---	2	144	4	149
PeB	Paumalu silty clay, 3 to 8 percent slopes--------------------	111	IIe	IIe	--	---	--	---	8	145	7	151
PeC	Paumalu silty clay, 8 to 15 percent slopes--------------------	111	IIIe	IIIe	--	---	--	---	8	145	7	151
PeD	Paumalu silty clay, 15 to 25 percent slopes--------------------	110	IVe	IVe	--	---	--	---	8	145	7	151
PeE	Paumalu silty clay, 25 to 40 percent slopes--------------------	111	VIe	VIe	--	---	--	---	8	145	7	151
PeF	Paumalu silty clay, 40 to 70 percent slopes--------------------	111	---	VIIe	--	---	--	---	8	145	14	152
PfB	Pauwela clay, 3 to 7 percent slopes-------------------------	111	---	IIe	--	---	7	141	8	145	7	151
PfC	Pauwela clay, 7 to 15 percent slopes-------------------------	112	---	IIIe	--	---	8	141	8	145	7	151
PfD	Pauwela clay, 15 to 25 percent slopes-------------------------	112	---	IVe	--	---	8	141	8	145	7	151
Ph	Pearl Harbor clay----------------	112	IVw	IVw	--	---	--	---	7	145	4	149
PkB	Pohakupu silty clay loam, 0 to 8 percent slopes-----------------	113	IIe	IIIe	1	136	--	---	6	145	5	150
PkC	Pohakupu silty clay loam, 8 to 15 percent slopes-----------------	113	---	IIIe	1	136	--	---	6	145	5	150
PlB	Pooku silty clay loam, 3 to 8 percent slopes-----------------	114	---	IIIs	2	136	--	---	10	146	9	151
PlD	Pooku silty clay loam, 8 to 25 percent slopes-----------------	114	---	IVe	2	136	--	---	10	146	9	151
PmB	Pooku silty clay, 0 to 8 percent slopes--------------------	114	---	IIIs	2	136	--	---	10	146	9	151
PmC	Pooku silty clay, 8 to 15 percent slopes--------------------	114	---	IIIe	2	136	--	---	10	146	9	151
PmD	Pooku silty clay, 15 to 25 percent slopes--------------------	114	---	IVe	2	136	--	---	10	146	9	151
PmE	Pooku silty clay, 25 to 40 percent slopes--------------------	114	---	VIe	--	---	--	---	10	146	9	151
PnA	Puhi silty clay loam, 0 to 3 percent slopes-----------------	115	IIs	IIs	1	136	4	139	8	145	7	151
PnB	Puhi silty clay loam, 3 to 8 percent slopes-----------------	115	IIe	IIe	1	136	5	140	8	145	7	151
PnC	Puhi silty clay loam, 8 to 15 percent slopes-----------------	115	IIIe	IIIe	1	136	6	140	8	145	7	151
PnD	Puhi silty clay loam, 15 to 25 percent slopes-----------------	115	IVe	IVe	1	136	6	140	8	145	7	151
PnE	Puhi silty clay loam, 25 to 40 percent slopes-----------------	115	---	VIe	--	---	--	---	8	145	7	151
PoB	Pulehu sandy loam, 2 to 6 percent slopes-------------------------	116	IIIe	VIs	1	136	--	---	2	144	--	---
PoaB	Pulehu stony sandy loam, 0 to 7 percent slopes-----------------	117	IIIe	VIs	1	136	--	---	2	144	--	---
PpA	Pulehu silt loam, 0 to 3 percent slopes------------------------	116	I	IVc	1	136	--	---	2	144	--	---
PpB	Pulehu silt loam, 3 to 7 percent slopes------------------------	116	IIe	IVc	1	136	--	---	2	144	--	---
PrA	Pulehu cobbly silt loam, 0 to 3 percent slopes-----------------	116	IIs	IVs	1	136	--	---	2	144	--	---

Map symbol	Mapping unit	Described on page	Capability classification: Irrigated Symbol	Capability classification: Nonirrigated Symbol	Sugarcane group No.	Sugarcane group Page	Pineapple group No.	Pineapple group Page	Pasture group No.	Pasture group Page	Woodland group No.	Woodland group Page
PrB	Pulehu cobbly silt loam, 3 to 7 percent slopes-----------------	116	IIe	IVs	1	136	--	---	2	144	--	---
PsA	Pulehu clay loam, 0 to 3 percent slopes--------------------	115	I	IVc	1	136	--	---	2	144	--	---
PtA	Pulehu cobbly clay loam, 0 to 3 percent slopes-----------------	116	IIs	IVs	1	136	--	---	2	144	--	---
PtB	Pulehu cobbly clay loam, 3 to 7 percent slopes-----------------	116	IIe	IVs	1	136	--	---	2	144	--	---
PuB	Pulehu stony clay loam, 2 to 6 percent slopes-----------------	116	IIe	IVs	1	136	--	---	2	144	--	---
PvC	Pulehu very stony clay loam, 0 to 12 percent slopes-----------	116	---	IVs	1	136	--	---	2	144	--	---
PwC	Puu Opae silty clay loam, 8 to 15 percent slopes--------------	117	IIIe	IIIe	--	---	--	---	6	145	5	150
PwD	Puu Opae silty clay loam, 15 to 25 percent slopes--------------	118	IVe	IVe	--	---	--	---	6	145	5	150
PwE	Puu Opae silty clay loam, 25 to 40 percent slopes--------------	118	---	VIe	--	---	--	---	6	145	5	150
UwB	Uwala silty clay loam, 2 to 7 percent slopes-----------------	123	IIe	IVc	--	---	2	138	2	144	--	---
UwC	Uwala silty clay loam, 7 to 15 percent slopes-----------------	124	IIIe	IVe	--	---	3	139	2	144	--	---
UwC3	Uwala silty clay loam, 7 to 15 percent slopes, severely eroded------------------------	124	IVe	IVe	--	---	3	139	2	144	--	---
WaA	Wahiawa silty clay, 0 to 3 percent slopes--------------------	124	I	IIc	1	136	4	139	5	145	5	150
WaB	Wahiawa silty clay, 3 to 8 percent slopes--------------------	125	IIe	IIe	1	136	5	140	5	145	5	150
WaC	Wahiawa silty clay, 8 to 15 percent slopes--------------------	125	IIIe	IIIe	1	136	6	140	5	145	5	150
WaD2	Wahiawa silty clay, 15 to 25 percent slopes, eroded------------	125	---	IVe	1	136	6	140	5	145	5	150
WbB	Wahikuli silty clay, 3 to 7 percent slopes--------------------	125	IIe	IVs	1	136	--	---	3	144	--	---
WcB	Wahikuli stony silty clay, 3 to 7 percent slopes-----------------	126	IIe	IVs	1	136	--	---	3	144	--	---
WcC	Wahikuli stony silty clay, 7 to 15 percent slopes--------------	126	IIIe	IVe	1	136	--	---	3	144	--	---
WdB	Wahikuli very stony silty clay, 3 to 7 percent slopes----------	126	IVs	VIs	1	136	--	---	3	144	--	---
WeB	Waiakoa silty clay loam, 3 to 7 percent slopes-----------------	127	IIe	VIs	1	136	--	---	1	143	--	---
WeC	Waiakoa silty clay loam, 7 to 15 percent slopes-----------------	127	IIIe	VIe	1	136	--	---	1	143	--	---
WfB	Waiakoa cobbly silty clay loam, 3 to 7 percent slopes----------	127	IIe	VIs	1	136	--	---	1	143	--	---
WgB	Waiakoa very stony silty clay loam, 3 to 7 percent slopes----	126	IVs	VIs	1	136	--	---	1	143	--	---
WgC	Waiakoa very stony silty clay loam, 7 to 15 percent slopes---	127	IVs	VIs	1	136	--	---	1	143	--	---
WhB	Waiakoa extremely stony silty clay loam, 3 to 7 percent slopes-----------------------	127	---	VIIs	--	---	--	---	1	143	--	---

Map symbol	Mapping unit	Described on page	Capability classification: Irrigated	Capability classification: Nonirrigated	Sugarcane group		Pineapple group		Pasture group		Woodland group	
			Symbol	Symbol	No.	Page	No.	Page	No.	Page	No.	Page
WhC	Waiakoa extremely stony silty clay loam, 7 to 15 percent slopes	127	---	VIIs	--	---	--	---	1	143	--	---
WkA	Waialua silty clay, 0 to 3 percent slopes	128	I	IIIc	4	137	--	---	3	144	1	149
WkB	Waialua silty clay, 3 to 8 percent slopes	128	IIe	IIIc	4	137	--	---	3	144	1	149
WlB	Waialua stony silty clay, 3 to 8 percent slopes	128	IIIe	IIIs	4	137	--	---	3	144	1	149
WlE	Waialua stony silty clay, 12 to 30 percent slopes	129	---	IVe	--	---	--	---	3	144	1	149
WmD	Waialua very stony silty clay, 12 to 20 percent slopes	129	---	VIs	--	---	--	---	3	144	1	149
WnB	Waialua clay, 2 to 6 percent slopes	129	IIe	IIIc	4	137	--	---	3	144	1	149
WoA	Waihuna clay, 0 to 3 percent slopes	129	IIs	IIIs	--	---	1	137	3	144	--	---
WoB	Waihuna clay, 3 to 7 percent slopes	130	IIe	IIIs	--	---	2	138	3	144	--	---
WoC	Waihuna clay, 7 to 15 percent slopes	130	IIIe	IIIe	--	---	3	139	3	144	--	---
WoD	Waihuna clay, 15 to 25 percent slopes	130	IVe	IVe	--	---	3	139	3	144	--	---
WohB	Waihuna gravelly clay, 3 to 7 percent slopes	130	IIe	IIIs	--	---	2	138	3	144	--	---
WpB	Waikane silty clay, 3 to 8 percent slopes	131	IIe	IIe	--	---	--	---	8	145	7	151
WpC	Waikane silty clay, 8 to 15 percent slopes	131	IIIe	IIIe	--	---	--	---	8	145	7	151
WpE	Waikane silty clay, 25 to 40 percent slopes	130	---	VIe	--	---	--	---	8	145	7	151
WpF	Waikane silty clay, 40 to 70 percent slopes	131	---	VIIe	--	---	--	---	8	145	14	152
WpF2	Waikane silty clay, 40 to 70 percent slopes, eroded	131	---	VIIe	--	---	--	---	8	145	14	152
WpaE	Waikane stony silty clay, 15 to 30 percent slopes	131	---	VIe	--	---	--	---	8	145	7	151
WrA	Waikapu silty clay loam, 0 to 3 percent slopes	131	I	IVc	--	---	1	137	2	144	--	---
WrB	Waikapu silty clay loam, 3 to 7 percent slopes	132	IIe	IVc	--	---	2	138	2	144	--	---
WrB3	Waikapu silty clay loam, 3 to 7 percent slopes, severely eroded	132	IIIe	IVe	--	---	2	138	2	144	--	---
WrC3	Waikapu silty clay loam, 7 to 15 percent slopes, severely eroded	132	IVe	IVe	--	---	3	139	2	144	--	---
Ws	Waikomo stony silty clay	132	IVs	VIs	1	136	--	---	5	145	13	152
Wt	Waikomo very rocky silty clay	133	VIs	VIs	--	---	--	---	5	145	13	152
Wu	Waikomo extremely rocky silty clay	133	---	VIIs	--	---	--	---	5	145	13	152
WvB	Wailuku silty clay, 3 to 7 percent slopes	133	IIe	IIIc	1	136	--	---	3	144	1	149
WvC	Wailuku silty clay, 7 to 15 percent slopes	133	IIIe	IIIe	1	136	--	---	3	144	1	149
WwC	Wailuku cobbly silty clay, 7 to 15 percent slopes	133	IIIe	IIIe	1	136	--	---	3	144	1	149

GUIDE TO MAPPING UNITS--Continued

Map symbol	Mapping unit	Described on page	Capability classification: Irrigated Symbol	Capability classification: Nonirrigated Symbol	Sugarcane group No.	Sugarcane group Page	Pineapple group No.	Pineapple group Page	Pasture group No.	Pasture group Page	Woodland group No.	Woodland group Page
WxB	Wainee very stony silty clay, 3 to 7 percent slopes	134	IVs	VIs	1	136	--	---	1	143	--	---
WxC	Wainee very stony silty clay, 7 to 15 percent slopes	134	IVs	VIs	1	136	--	---	1	143	--	---
WyB	Wainee extremely stony silty clay, 3 to 7 percent slopes	134	VIs	VIs	--	---	--	---	1	143	--	---
WyC	Wainee extremely stony silty clay, 7 to 15 percent slopes	134	VIs	VIs	--	---	--	---	1	143	--	---
WzA	Waipahu silty clay, 0 to 2 percent slopes	134	I	IVc	1	136	--	---	3	144	--	---
WzB	Waipahu silty clay, 2 to 6 percent slopes	135	IIe	IVc	1	136	--	---	3	144	--	---
WzC	Waipahu silty clay, 6 to 12 percent slopes	135	IIIe	IVe	1	136	--	---	3	144	--	---

LOW-INTENSITY SURVEY

Map symbol	Mapping unit	Described on page	Capability classification: Irrigated Symbol	Capability classification: Nonirrigated Symbol	Sugarcane group No.	Sugarcane group Page	Pineapple group No.	Pineapple group Page	Pasture group No.	Pasture group Page	Woodland group No.	Woodland group Page
ALE3	Alaeloa silty clay, 15 to 35 percent slopes, severely eroded	27	---	VIIe	--	---	--	---	6	145	5	150
ALF	Alaeloa silty clay, 40 to 70 percent slopes	26	---	VIIe	--	---	--	---	6	145	15	152
AME3	Alaeloa stony silty clay, 15 to 35 percent slopes, severely eroded	27	---	VIIe	--	---	--	---	6	145	5	150
ANE	Alaeloa stony silty clay, overwash, 15 to 35 percent slopes	27	---	VIe	--	---	--	---	6	145	5	150
BL	Badland	28	---	VIIIe	--	---	--	---	--	---	--	---
BM	Badland-Mahana complex	28										
	Badland	--	---	VIIIe	--	---	--	---	--	---	--	---
	Mahana	--	---	VIe	--	---	--	---	6	145	5	150
BS	Beaches	28	---	VIIIw	--	---	--	---	--	---	--	---
BW	Blown-out land	28	---	VIIe	--	---	--	---	--	---	--	---
CO	Colluvial land	29	---	VIIe	--	---	--	---	--	---	15	152
CR	Coral outcrop	29	---	VIIIs	--	---	--	---	--	---	--	---
DL	Dune land	29	---	VIIIe	--	---	--	---	--	---	--	---
FL	Fill land, mixed	31	---	---	--	---	--	---	--	---	--	---
GL	Gullied land	31	---	VIIe	--	---	--	---	--	---	--	---
HID	Halawa silty clay, 3 to 25 percent slopes	32	IVe	IVe	--	---	--	---	6	145	5	150
HID3	Halawa silty clay, 3 to 25 percent slopes, severely eroded	33	VIe	VIe	--	---	--	---	6	145	5	150
HJE	Halawa silt loam, 20 to 35 percent slopes	33	---	VIe	--	---	--	---	6	145	5	150
HJF2	Halawa silt loam, 35 to 70 percent slopes, eroded	33	---	VIIe	--	---	--	---	6	145	15	152
HKLD	Hana very stony silty clay loam, 3 to 25 percent slopes	37	---	VIs	--	---	--	---	11	147	8	151
HKMD	Hana extremely stony silty clay loam, 3 to 25 percent slopes	37	---	VIs	--	---	--	---	11	147	8	151
HKNC	Hana silty clay loam, moderately deep variant, 3 to 15 percent slopes	37	---	IIIe	--	---	--	---	11	147	8	151

Map symbol	Mapping unit	Described on page	Capability classification: Irrigated Symbol	Capability classification: Nonirrigated Symbol	Sugarcane group No.	Sugarcane group Page	Pineapple group No.	Pineapple group Page	Pasture group No.	Pasture group Page	Woodland group No.	Woodland group Page
HKOC	Hana extremely stony silty clay loam, moderately deep variant, 3 to 15 percent slopes	37	---	VIs	--	---	--	---	9	146	8	151
HLMG	Helemano silty clay, 30 to 90 percent slopes	40	---	VIIe	--	---	--	---	3	144	15	152
HMMF	Hihimanu silty clay loam, 40 to 70 percent slopes	40	---	VIIe	--	---	--	---	8	145	14	152
HNUD	Hulua gravelly silty clay loam, 3 to 25 percent slopes	46	---	VIe	--	---	--	---	--	---	16	152
HNUF	Hulua gravelly silty clay loam, 25 to 70 percent slopes	45	---	VIIe	--	---	--	---	--	---	16	152
ISD	Io silt loam, 7 to 25 percent slopes	47	---	IVe	--	---	--	---	4	144	2	149
JL	Jaucas-Blown-out land complex	49	---	VIe	--	---	--	---	1	143	--	---
KASD	Kahanui silty clay, 3 to 20 percent slopes	52	---	VIe	--	---	--	---	8	145	12	152
KATD	Kahanui gravelly silty clay, 3 to 20 percent slopes	51	---	VIe	--	---	--	---	8	145	12	152
KBID	Kailua silty clay, 3 to 25 percent slopes	53	---	IVe	--	---	--	---	11	147	8	151
KCXD	Kaimu extremely stony peat, 7 to 25 percent slopes	53	---	VIs	--	---	--	---	5	145	3	149
KDIE	Kaipoioi loam, 7 to 40 percent slopes	54	---	VIe	--	---	--	---	13	148	11	151
KDVE	Kaipoioi very rocky loam, 7 to 40 percent slopes	54	---	VIs	--	---	--	---	13	148	11	151
KEHF	Kalapa very rocky silty clay, 40 to 70 percent slopes	56	---	VIIs	--	---	--	---	8	145	14	152
KFID	Kalaupapa very rocky silty clay loam, 3 to 25 percent slopes	56	---	VIIs	--	---	--	---	5	145	13	152
KGKC	Kamaole very stony silt loam, 3 to 15 percent slopes	59	---	VIs	--	---	--	---	3	144	--	---
KGLC	Kamaole extremely stony silt loam, 3 to 15 percent slopes	59	---	VIs	--	---	--	---	3	144	--	---
KHMC	Kaneohe silty clay loam, 5 to 15 percent slopes	60	---	IIIe	--	---	--	---	8	145	7	151
KHME	Kaneohe silty clay loam, 15 to 30 percent slopes	60	---	VIe	--	---	--	---	8	145	7	151
KHMF	Kaneohe silty clay loam, 30 to 65 percent slopes	60	---	VIIe	--	---	--	---	8	145	14	152
KHOF	Kaneohe silty clay, 30 to 65 percent slopes	60	---	VIIe	--	---	--	---	8	145	14	152
KIG	Kapaa silty clay, 40 to 100 percent slopes	62	---	VIIe	--	---	--	---	10	146	14	152
KKTC	Kapuhikani extremely stony clay, 3 to 15 percent slopes	62	---	VIIs	--	---	--	---	1	143	--	---
KLUD	Kaupo very stony silty clay loam, 3 to 25 percent slopes	63	---	VIs	--	---	--	---	3	144	1	149
KLVD	Kaupo extremely stony silty clay, 3 to 25 percent slopes	63	---	VIs	--	---	--	---	3	144	1	149
KMW	Kealia silt loam	67	---	VIIw	--	---	--	---	1	143	--	---
KNXD	Keawakapu extremely stony silty clay loam, 3 to 25 percent slopes	68	---	VIs	--	---	--	---	1	143	--	---
KOYE	Kekaha extremely stony silty clay loam, 0 to 35 percent slopes	69	---	VIs	--	---	--	---	2	144	4	149

Map symbol	Mapping unit	Described on page	Capability classification: Irrigated Symbol	Capability classification: Nonirrigated Symbol	Sugarcane group No.	Sugarcane group Page	Pineapple group No.	Pineapple group Page	Pasture group No.	Pasture group Page	Woodland group No.	Woodland group Page
KPZ	Kemoo-Badland complex	70										
	Kemoo	--	---	VIIe	--	---	--	---	5	145	5	150
	Badland	--	---	VIIIe	--	---	--	---	--	---	--	---
KRL	Koele-Badland complex	71										
	Koele	--	---	VIe	--	---	--	---	3	144	--	---
	Badland	--	---	VIIIe	--	---	--	---	--	---	--	---
KRX	Koele rocky complex	71	---	VIs	--	---	--	---	3	144	--	---
KSKE	Kokee silty clay loam, 0 to 35 percent slopes	71	---	VIe	--	---	--	---	12	147	10	151
KSKF	Kokee silty clay loam, 35 to 70 percent slopes	72	---	VIIe	--	---	--	---	12	147	10	151
KTKE	Kokokahi very stony clay, 0 to 35 percent slopes	73	---	VIs	--	---	--	---	3	144	--	---
KUL	Kolokolo extremely stony clay loam	75	---	VIIs	--	---	--	---	8	145	7	151
KVSB	Koolau silty clay, 0 to 8 percent slopes	76	---	VIw	--	---	--	---	11	147	16	152
KVSE	Koolau silty clay, 8 to 30 percent slopes	76	---	VIw	--	---	--	---	11	147	16	152
KZC	Kunuweia very gravelly clay loam, 0 to 15 percent slopes	78	---	VIs	--	---	--	---	12	147	12	152
LME	Laumaia loam, 7 to 40 percent slopes	80	---	VIe	--	---	--	---	13	148	11	151
LMF	Laumaia loam, 40 to 70 percent slopes	80	---	VIIe	--	---	--	---	13	148	11	151
LNE	Laumaia extremely stony loam, 7 to 40 percent slopes	80	---	VIIs	--	---	--	---	13	148	11	151
LPE	Lualualei extremely stony clay, 3 to 35 percent slopes	85	---	VIIs	--	---	--	---	2	144	4	149
MBL	Mahana-Badland complex	86										
	Mahana	--	---	IVe	--	---	--	---	6	145	5	150
	Badland	--	---	VIIIe	--	---	--	---	--	---	--	---
MID	Makaalae silty clay, 7 to 25 percent slopes	87	---	IVe	--	---	--	---	8	145	7	151
MJD	Makaalae extremely stony silty clay, 7 to 25 percent slopes	87	---	VIIs	--	---	--	---	8	145	7	151
MWE	Makaalae clay, 7 to 40 percent slopes	87	---	VIe	--	---	--	---	8	145	7	151
MXC	Makena loam, stony complex, 3 to 15 percent slopes	91										
	Makena	--	---	VIs	--	---	--	---	1	143	--	---
	Stony land	--	---	VIIs	--	---	--	---	--	---	--	---
MYD	Malama extremely stony muck, 3 to 25 percent slopes	93	---	VIs	--	---	--	---	9	146	8	151
MZ	Marsh	95	---	VIIIw	--	---	--	---	--	---	--	---
NAC	Naiwa silty clay loam, 3 to 20 percent slopes	97	---	IVe	--	---	--	---	6	145	5	150
NAC3	Naiwa silty clay loam, 7 to 15 percent slopes, severely eroded	98	---	VIe	--	---	--	---	6	145	5	150
NLE	Niulii silty clay loam, 7 to 30 percent slopes	99	---	VIe	--	---	--	---	9	146	8	151
NME	Niulii silty clay loam, medium textured variant, 7 to 30 percent slopes	99	---	VIe	--	---	--	---	9	146	8	151

Map symbol	Mapping unit	Described on page	Capability classification: Irrigated	Capability classification: Nonirrigated	Sugarcane group		Pineapple group		Pasture group		Woodland group	
			Symbol	Symbol	No.	Page	No.	Page	No.	Page	No.	Page
OAD	Oanapuka very stony silt loam, 7 to 25 percent slopes	101	---	VIs	--	---	--	---	2	144	--	---
OED	Oanapuka extremely stony silt loam, 7 to 25 percent slopes	101	---	VIIs	--	---	--	---	2	144	--	---
OFC	Olelo silty clay, 3 to 15 percent slopes	101	---	IIIe	--	---	--	---	8	145	7	151
OMB	Oli silt loam, 3 to 10 percent slopes	103	---	IVe	--	---	--	---	6	145	5	150
OME	Oli silt loam, 10 to 30 percent slopes	102	---	VIe	--	---	--	---	6	145	5	150
OMF	Oli silt loam, 30 to 70 percent slopes	103	---	VIIe	--	---	--	---	6	145	15	152
ONC	Olinda loam, 4 to 12 percent slopes	103	---	IIIe	--	---	--	---	12	147	10	151
OND	Olinda loam, 12 to 20 percent slopes	103	---	IVe	--	---	--	---	12	147	10	151
ONE	Olinda loam, 20 to 40 percent slopes	104	---	VIe	--	---	--	---	12	147	10	151
OOE	Olokui silty clay loam, 3 to 30 percent slopes	104	---	VIIw	--	---	--	---	--	---	16	152
OPD	Opihikao extremely rocky muck, 3 to 25 percent slopes	105	---	VIs	--	---	--	---	9	146	--	---
PGE	Paaiki loam, 6 to 35 percent slopes	105	---	VIe	--	---	--	---	12	147	10	151
PGF	Paaiki loam, 35 to 70 percent slopes	106	---	VIIe	--	---	--	---	12	147	10	151
PHXC	Pakala extremely stony sandy clay loam, 0 to 12 percent slopes	108	---	VIIs	--	---	--	---	2	144	4	149
PID	Pamoa silty clay, 5 to 20 percent slopes	108	---	IVe	--	---	--	---	3	144	--	---
PID2	Pamoa silty clay, 5 to 20 percent slopes, eroded	109	---	VIe	--	---	--	---	3	144	--	---
PJD2	Pamoa stony silty clay, 5 to 20 percent slopes, eroded	109	---	VIe	--	---	--	---	3	144	--	---
PXD	Pane silt loam, 7 to 25 percent slopes	109	---	IVe	--	---	--	---	5	145	3	149
PYD	Papaa clay, 6 to 20 percent slopes	110	---	IVe	-	---	--	---	3	144	1	149
PYE	Papaa clay, 20 to 35 percent slopes	110	---	VIe	--	---	--	---	3	144	1	149
PYF	Papaa clay, 35 to 70 percent slopes	110	---	VIIe	--	---	--	---	3	144	1	149
PZ	Paumalu-Badland complex	111										
	Paumalu	--	---	VIIe	--	---	--	---	8	145	7	151
	Badland	--	---	VIIIe	--	---	--	---	--	---	--	---
PZUE	Puuone sand, 7 to 30 percent slopes	117	---	VIIe	-	---	--	---	1	143	--	---
PZVE	Puu Pa very stony silt loam, 7 to 40 percent slopes	118	---	VIs	--	---	--	---	2	144	--	---
TAE	Tantalus silt loam, 15 to 40 percent slopes	121	---	VIe	--	---	--	---	9	146	8	151
TAF	Tantalus silt loam, 40 to 70 percent slopes	121	---	VIIe	--	---	--	---	9	146	8	151
TCC	Tantalus silty clay loam, 8 to 15 percent slopes	121	---	IIIe	--	---	--	---	9	146	8	151

Map symbol	Mapping unit	Described on page	Capability classification: Irrigated Symbol	Capability classification: Nonirrigated Symbol	Sugarcane group No.	Sugarcane group Page	Pineapple group No.	Pineapple group Page	Pasture group No.	Pasture group Page	Woodland group No.	Woodland group Page
TCE	Tantalus silty clay loam, 15 to 40 percent slopes------------------	121	---	VIe	--	---	--	---	9	146	8	151
TR	Tropaquepts----------------------	121	IVw	IVw	--	---	--	---	--	---	--	---
ULD	Ulupalakua silt loam, 7 to 25 percent slopes--------------------	122	---	IVe	--	---	--	---	5	145	3	149
UME	Uma loamy coarse sand, 15 to 40 percent slopes------------------	123	---	VIs	--	---	--	---	4	144	11	151
UMF	Uma loamy coarse sand, 40 to 70 percent slopes------------------	123	---	VIIs	--	---	--	---	4	144	11	151
URD	Uma rocky loamy coarse sand, 7 to 25 percent slopes---------------	123	--	VIs	--	---	--	---	4	144	11	151
WID2	Waiakoa extremely stony silty clay loam, 3 to 25 percent slopes, eroded------------------------	127	---	VIIs	--	---	--	---	1	143	--	---
WJF	Waiawa extremely rocky clay, 30 to 80 percent slopes------------	129	---	VIIs	--	---	--	---	2	144	--	---

RECONNAISSANCE SURVEY

Map symbol	Mapping unit	Described on page	Capability classification: Irrigated Symbol	Capability classification: Nonirrigated Symbol	Sugarcane group No.	Sugarcane group Page	Pineapple group No.	Pineapple group Page	Pasture group No.	Pasture group Page	Woodland group No.	Woodland group Page
rAAE	Alakai mucky peat, 0 to 30 percent slopes--------------------	27	---	VIIw	--	---	--	---	--	---	16	152
rAMD	Amalu peaty silty clay, 3 to 20 percent slopes------------------	28	---	VIIw	--	---	--	---	--	---	16	152
rAOD	Amalu-Olokui association, 3 to 20 percent slopes------------------	28										
	Amalu------------------------	--	---	VIIw	--	---	--	---	--	---	16	152
	Olokui-----------------------	--	---	VIIIw	--	---	--	---	--	---	16	152
rCI	Cinder land----------------------	29	---	VIIIs	--	---	--	---	--	---	--	---
rHOD	Honomanu silty clay, 5 to 25 percent slopes---------------------	43	---	IVe	--	---	--	---	11	147	8	151
rHR	Honomanu-Amalu association--------	43										
	Honomanu---------------------	--	---	IVe	--	---	--	---	--	---	8	151
	Amalu------------------------	--	---	VIIw	--	---	--	---	--	---	--	---
rHT	Hydrandepts-Tropaquods association--------------------	46										
	Hydrandepts------------------	--	---	VIIe	--	---	--	---	--	---	--	---
	Tropaquods-------------------	--	---	VIIw	--	---	--	---	--	---	--	---
rLW	Lava flows, Aa-------------------	80	---	VIIIs	--	---	--	---	--	---	--	---
rRH	Riverwash------------------------	118	---	VIIIw	--	---	--	---	--	---	--	---
rRK	Rock land------------------------	119	---	VIIs	--	---	--	---	--	---	--	---
rRO	Rock outcrop---------------------	119	---	VIIIs	--	---	--	---	--	---	--	---
rRR	Rough broken land----------------	119	---	VIIe	--	---	--	---	--	---	--	---
rRS	Rough broken and stony land-------	119	---	VIIs	--	---	--	---	--	---	--	---
rRT	Rough mountainous land------------	119	---	VIIIe	--	---	--	---	--	---	--	---
rRU	Rubble land----------------------	119	---	VIIIs	--	---	--	---	--	---	--	---
rSL	Sandy alluvial land---------------	119	---	VIIw	--	---	--	---	--	---	--	---
rSM	Stony alluvial land---------------	120	---	VIIs	--	---	--	---	--	---	--	---
rSN	Stony blown-out land--------------	120	---	VIIs	--	---	--	---	--	---	--	---
rSO	Stony colluvial land--------------	120	---	VIIs	--	---	--	---	--	---	--	---
rST	Stony land-----------------------	120	---	VIIs	--	---	--	---	--	---	--	---
rSY	Stony steep land-----------------	121	---	VIIs	--	---	--	---	--	---	--	---
rTO	Tropaquods-----------------------	121	---	VIIw	--	---	--	---	--	---	--	---
rTP	Tropohumults-Dystrandepts association--------------------	122	---	VIIe	--	---	--	---	--	---	--	---

Map symbol	Mapping unit	Described on page	Capability classification: Irrigated	Capability classification: Nonirrigated	Sugarcane group		Pineapple group		Pasture group		Woodland group	
			Symbol	Symbol	No.	Page	No.	Page	No.	Page	No.	Page
rVS	Very stony land	124	---	VIIs	--	---	--	---	--	---	--	---
rVT2	Very stony land, eroded	124	---	VIIs	--	---	--	---	--	---	--	---
rWAF	Waialeale mucky silty clay loam, 30 to 70 percent slopes	127	---	VIIe	--	---	--	---	--	---	16	152

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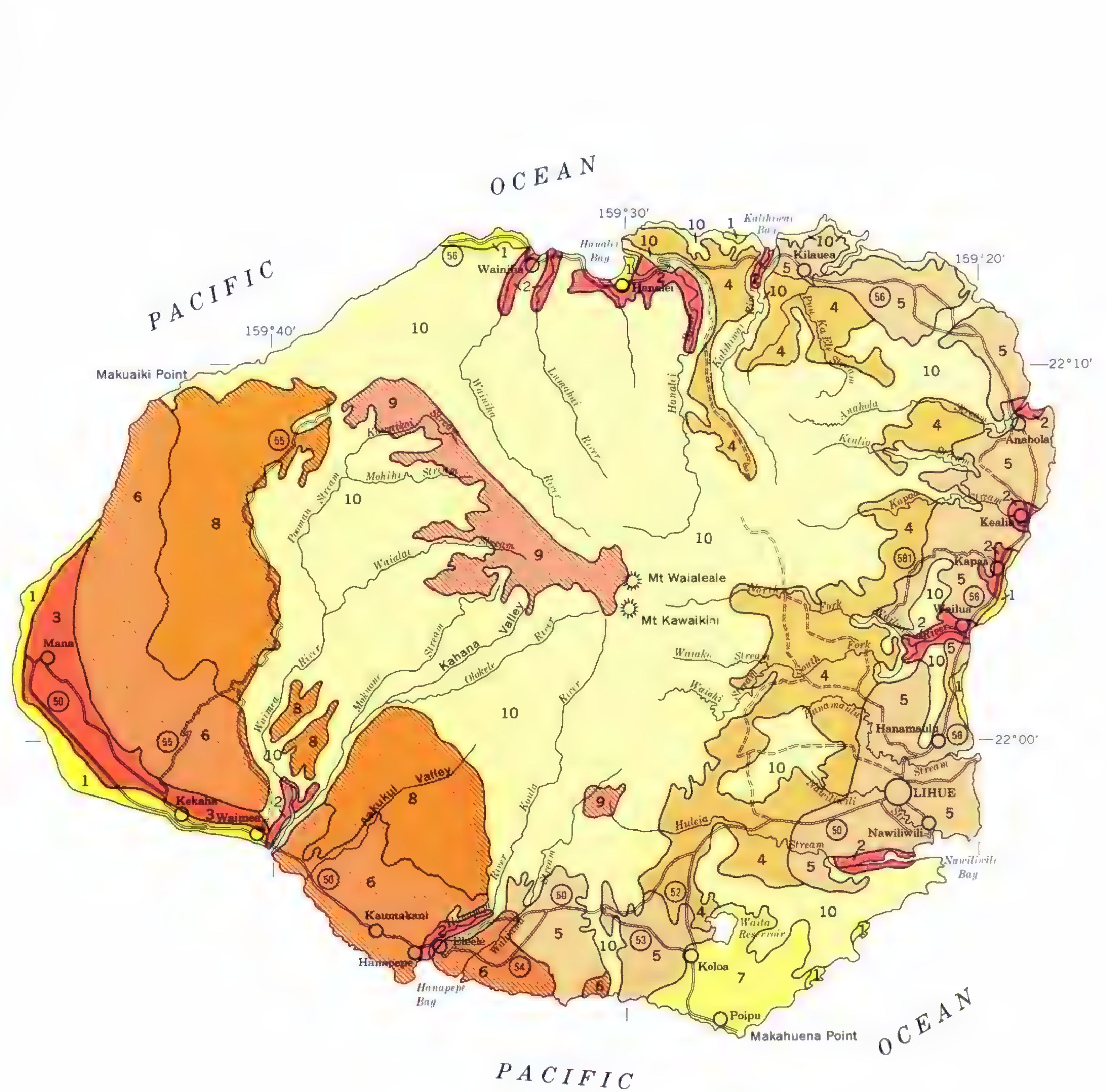
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
UNIVERSITY OF HAWAII AGRICULTURAL EXPERIMENT STATION

GENERAL SOIL MAP

KAUAI ISLAND, HAWAII

Scale 1:253,440



SOIL ASSOCIATIONS

1 — Jaucas-Mokuleia association: Deep, nearly level to moderately sloping, excessively drained and well-drained soils that have coarse-textured underlying material; on coastal plains

2 — Hanalei-Kolokolo-Pakala association: Deep, nearly level, poorly drained to well-drained soils that have dominantly moderately fine textured or medium-textured subsoil or underlying material; on bottom land

3 — Kekaha-Nohili association: Deep, nearly level, well-drained and poorly drained soils that have a fine-textured subsoil; on coastal plains

4 — Kapaa-Pooku-Halii-Makapili association: Deep, nearly level to steep, well drained and moderately well drained soils that have a fine textured or moderately fine textured subsoil; on uplands

5 — Lihue-Puhi association: Deep, nearly level to steep, well-drained soils that have a fine textured or moderately fine textured subsoil; on uplands

6 — Makaweli-Waiawa-Niu association: Deep, gently sloping to steep, well-drained soils that have a dominantly moderately fine textured or fine textured subsoil and shallow, steep and very steep, well-drained soils over basalt bedrock; on uplands

7 — Waikomo-Kalihi-Koloa association: Moderately deep, gently sloping, well-drained upland soils that have a moderately fine textured or fine textured subsoil; deep, nearly level, poorly drained, bottom-land soils that have a fine-textured subsoil

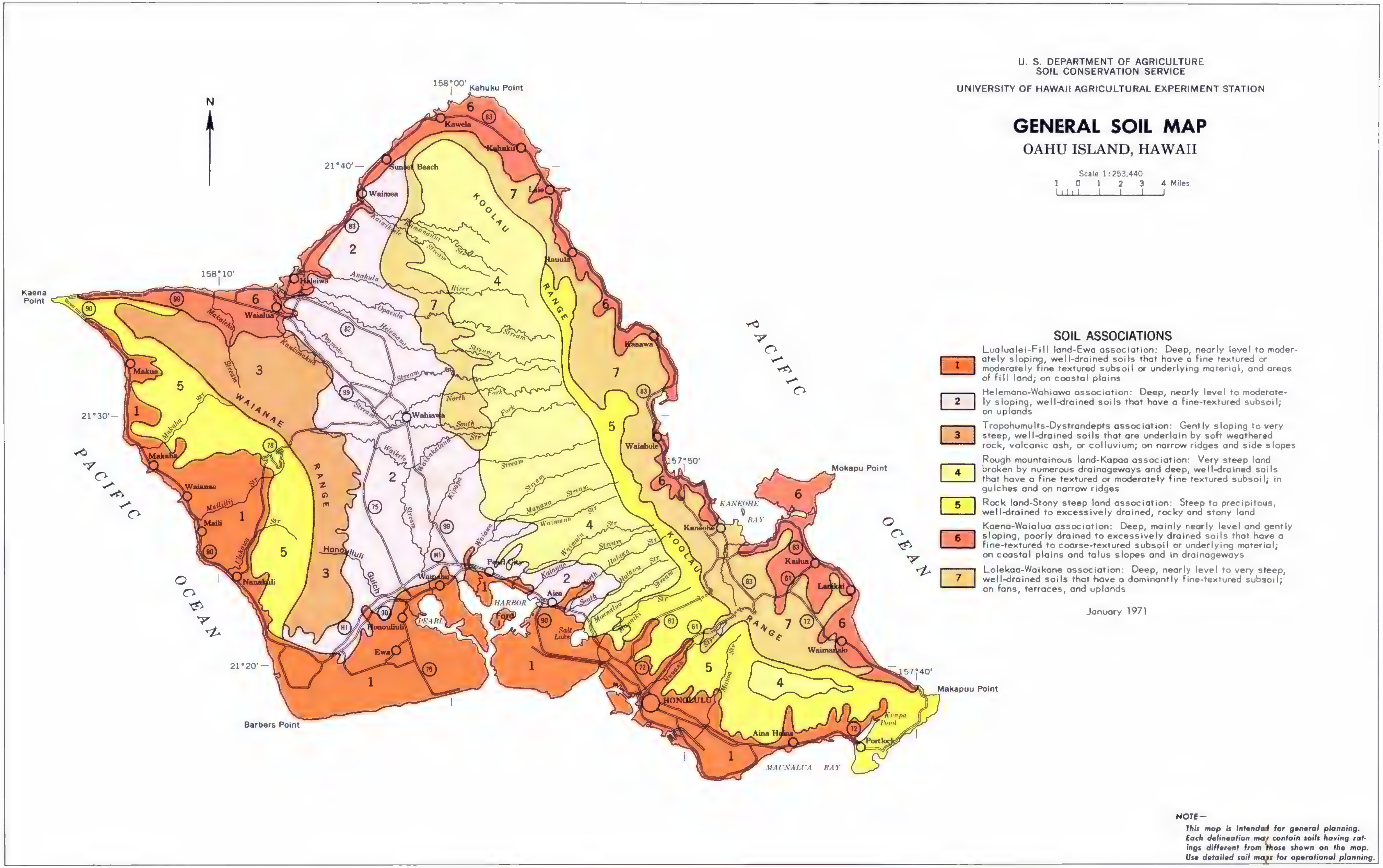
8 — Rough broken land-Mahana-Kokee association: Shallow to deep, very steep, rough broken land and deep, moderately sloping to very steep, well-drained soils that have a medium-textured to fine-textured subsoil; on uplands

9 — Waialeale-Alakai association: Moderately deep, very steep, somewhat poorly drained soils that have a moderately fine textured subsoil and level to moderately steep, very poorly drained organic soils over fine-textured material; on uplands

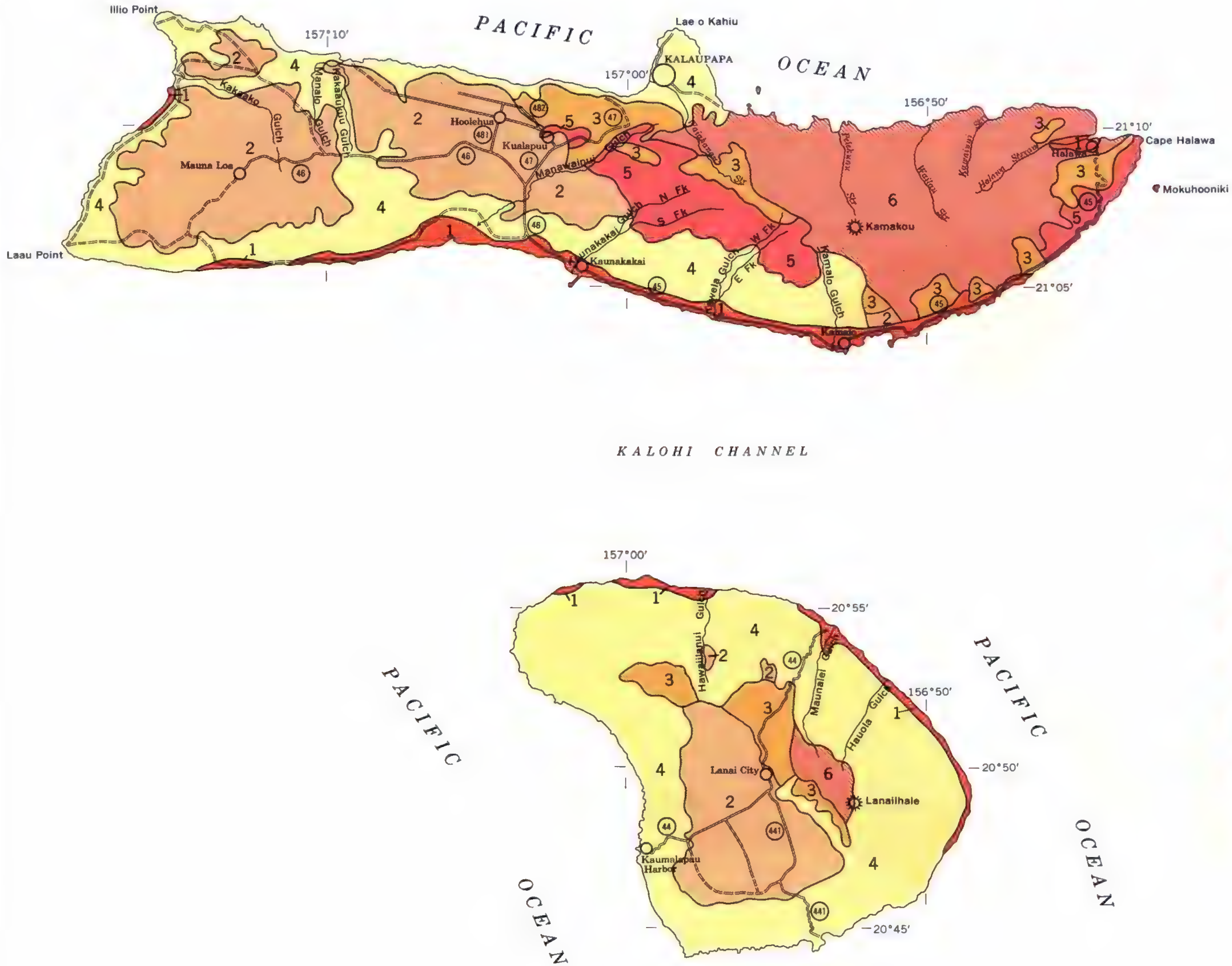
10 — Rough mountainous land-Rough broken land-Rock outcrop association: Well-drained to excessively drained, very steep to precipitous lands of mountains and gulches

January 1971

NOTE—
This map is intended for general planning. Each delineation may contain soils having ratings different from those shown on the map. Use detailed soil maps for operational planning.



U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
UNIVERSITY OF HAWAII AGRICULTURAL EXPERIMENT STATION
GENERAL SOIL MAP
OAHU ISLAND, HAWAII
Scale 1:253,440
1 0 1 2 3 4 Miles
SOIL ASSOCIATIONS
1 Lualualei-Fill land-Ewa association: Deep, nearly level to moderately sloping, well-drained soils that have a fine textured or moderately fine textured subsoil or underlying material, and areas of fill land; on coastal plains
2 Helemano-Wahiawa association: Deep, nearly level to moderately sloping, well-drained soils that have a fine-textured subsoil; on uplands
3 Tropohumults-Dystrandepts association: Gently sloping to very steep, well-drained soils that are underlain by soft weathered rock, volcanic ash, or colluvium; on narrow ridges and side slopes
4 Rough mountainous land-Kapaa association: Very steep land broken by numerous drainageways and deep, well-drained soils that have a fine textured or moderately fine textured subsoil; in gulches and on narrow ridges
5 Rock land-Stony steep land association: Steep to precipitous, well-drained to excessively drained, rocky and stony land
6 Kaena-Waialua association: Deep, mainly nearly level and gently sloping, poorly drained to excessively drained soils that have a fine-textured to coarse-textured subsoil or underlying material; on coastal plains and talus slopes and in drainageways
7 Lolekaa-Waikane association: Deep, nearly level to very steep, well-drained soils that have a dominantly fine-textured subsoil; on fans, terraces, and uplands
January 1971
NOTE—
This map is intended for general planning. Each delineation may contain soils having ratings different from those shown on the map. Use detailed soil maps for operational planning.
N
158°00'
Kahuku Point
21°40'
158°10'
21°30'
21°20'
157°50'
157°40'
Kaena Point
Barbers Point
Mokapu Point
Makapuu Point
PACIFIC OCEAN
PACIFIC OCEAN
Kawela
Kahuku
Sunset Beach
Waimea
Laie
Hauula
Haleiwa
Waialua
Kaaawa
Makua
Makaha
Waianae
Maili
Nanakuli
Wahiawa
Waiahole
Kaneohe
KANEOHE BAY
Kailua
Lanikai
Waimanalo
Pearl City
Waipahu
Honouliuli
Ewa
Aiea
Salt Lake
HONOLULU
Aina Haina
Portlock
Koko Pond
MAUNALUA BAY
PEARL HARBOR
Ford I.
KOOLAU RANGE
KOOLAU RANGE
WAIANAE RANGE
Kaukonahua
Opaeula
Helemano
Anahulu River
Kamananui Str
Kaiwiko ele Stream
Poamoho Stream
Makaleha Stream
Makaha Str
Mailiili Str
Ulehawa
Honouliuli Gulch
Waikele Stream
Wahiawa
Kipapa
North Fork
South Fork
Waimalu
Waimano
Manana
Halawa
Kalauao
Moanalua
Nuuanu
Manoa



N

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
UNIVERSITY OF HAWAII AGRICULTURAL EXPERIMENT STATION

GENERAL SOIL MAP
MOLOKAI AND LANAI ISLANDS, HAWAII

Scale 1:253,440

1 0 1 2 3 4 Miles

SOIL ASSOCIATIONS

1 Jaucas-Mala-Pulehu association: Deep, nearly level and gently sloping, excessively drained and well-drained soils that have coarse-textured to fine-textured underlying material; on alluvial fans and in drainageways

2 Molokai-Lahaina association: Deep, nearly level to moderately steep, well-drained soils that have a moderately fine textured or fine textured subsoil; on uplands

3 Kahanui-Kalae-Kanepuu association: Deep, gently sloping to moderately steep, well-drained soils that have a dominantly fine-textured subsoil; on uplands

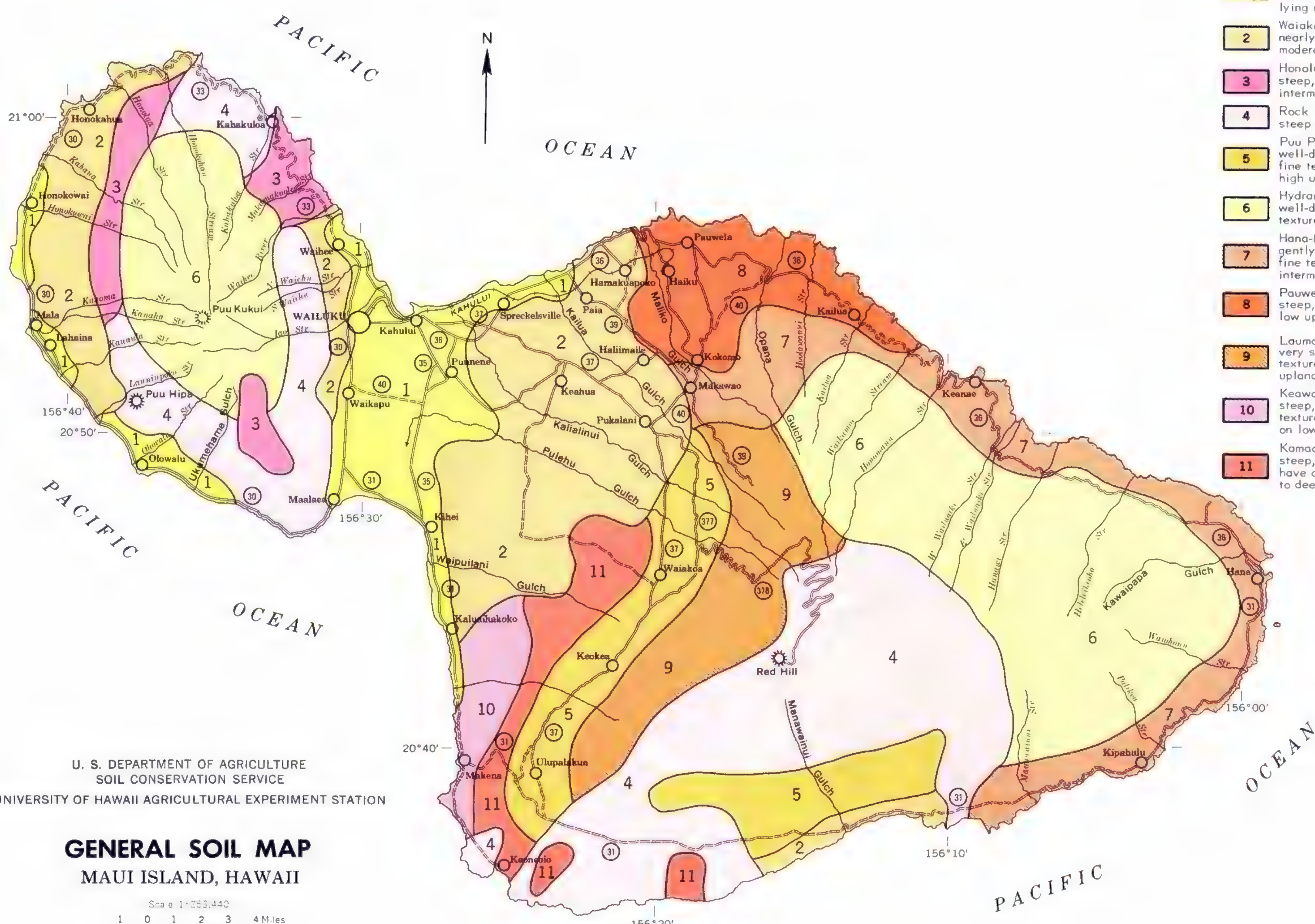
4 Very stony land-Rock land association: Gently sloping to very steep, rocky and stony land types; on uplands and in gulches and valleys

5 Rough broken land-Oli association: Shallow to deep, very steep to precipitous soils in gulches and moderately deep to deep, gently sloping to steep, well-drained soils that have a medium-textured and moderately fine textured subsoil; on uplands

6 Rough mountainous land-Amalu-Olokui association: Shallow, very steep lands of mountains and gulches and deep to shallow, gently sloping to hilly, poorly drained soils over soft weathered rock; on uplands

January 1971

NOTE—
This map is intended for general planning. Each delineation may contain soils having ratings different from those shown on the map. Use detailed soil maps for operational planning.



SOIL ASSOCIATIONS

1 — Pulehu-Ewa-Jaucas association: Deep, nearly level to moderately sloping, well-drained and excessively drained soils that have a moderately fine textured to coarse-textured subsoil or underlying material; on alluvial fans and in basins

2 — Waiakoa-Keahua-Molokai association: Moderately deep and deep, nearly level to moderately steep, well-drained soils that have a moderately fine textured subsoil; on low uplands

3 — Honolua-Olelo association: Deep, gently sloping to moderately steep, well-drained soils that have a fine-textured subsoil; on intermediate uplands

4 — Rock land-Rough mountainous land association: Very shallow, steep and very steep, rock land and rough mountain land

5 — Puu Pa-Kula-Pane association: Deep, gently sloping to steep, well-drained soils that have a medium-textured or moderately fine textured subsoil or underlying material; on intermediate and high uplands

6 — Hydrandepts-Tropaquods association: Gently sloping to steep, well-drained to poorly drained soils that have a moderately fine textured or fine textured subsoil; on intermediate and high uplands

7 — Hana-Makaalae-Kailua association: Moderately deep and deep, gently sloping to steep, well-drained soils that have a moderately fine textured or fine textured subsoil or underlying material; on intermediate uplands

8 — Pauwela-Haiku association: Deep, gently sloping to moderately steep, well-drained soils that have a fine-textured subsoil; on low uplands

9 — Laumaia-Kaipoioi-Olinda association: Deep, gently sloping to very steep, well-drained soils that have a moderately fine textured or medium-textured subsoil; on intermediate and high uplands

10 — Keawakapu-Makena association: Gently sloping to moderately steep, well-drained soils that have a fine-textured to medium-textured subsoil and are shallow to deep over fragmental lava; on low uplands

11 — Kamaole-Oanapuka association: Gently sloping to moderately steep, well-drained, very stony and extremely stony soils that have a fine-textured or medium-textured subsoil and are shallow to deep over fragmental lava; on low and intermediate uplands

January 1971

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
UNIVERSITY OF HAWAII AGRICULTURAL EXPERIMENT STATION

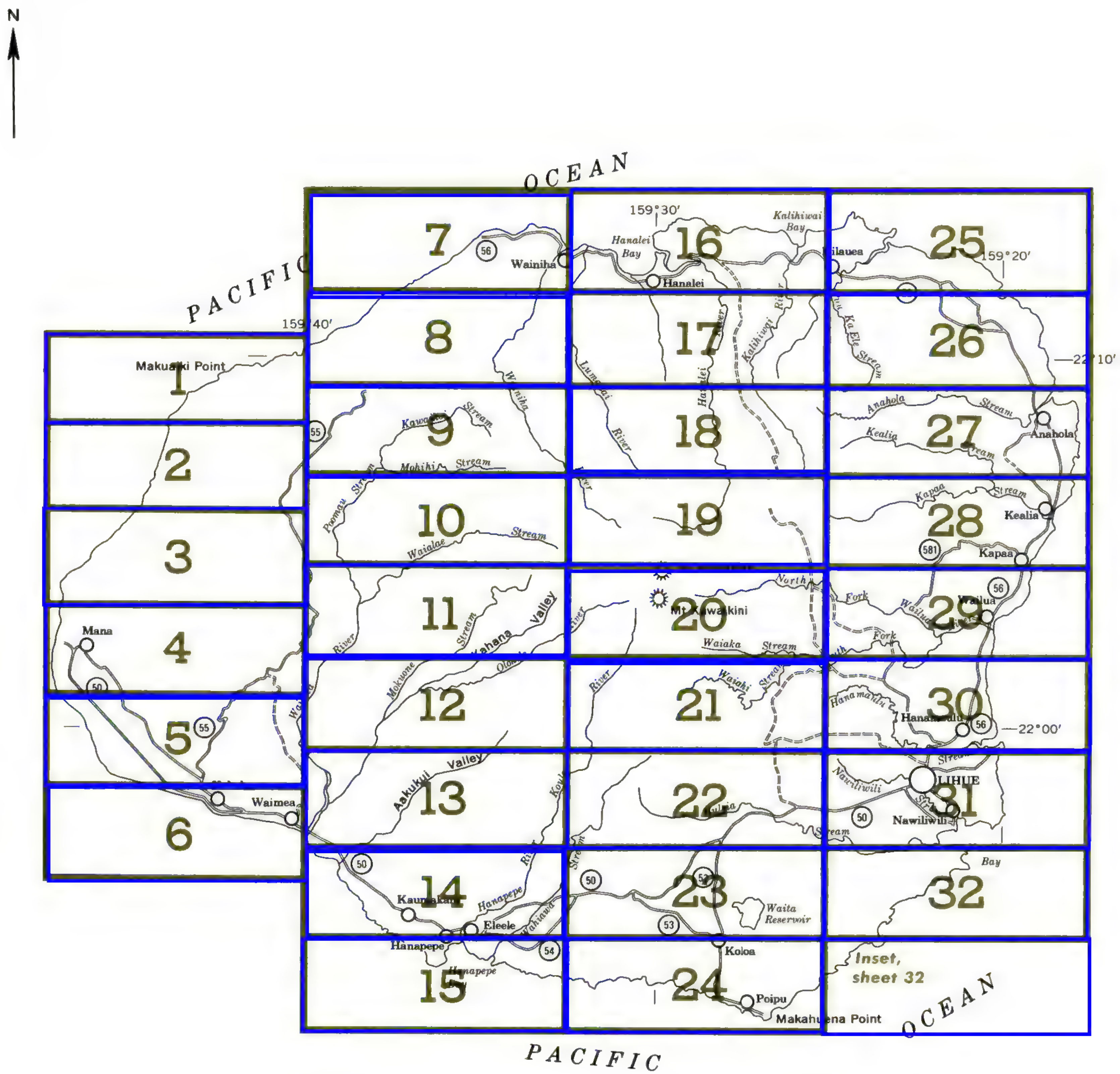
GENERAL SOIL MAP

MAUI ISLAND, HAWAII

Scale 1:253,440

1 0 1 2 3 4 Miles

NOTE—
This map is intended for general planning. Each delineation may contain soils having ratings different from those shown on the map. Use detailed soil maps for operational planning.



INDEX TO MAP SHEETS
KAUAI ISLAND, HAWAII

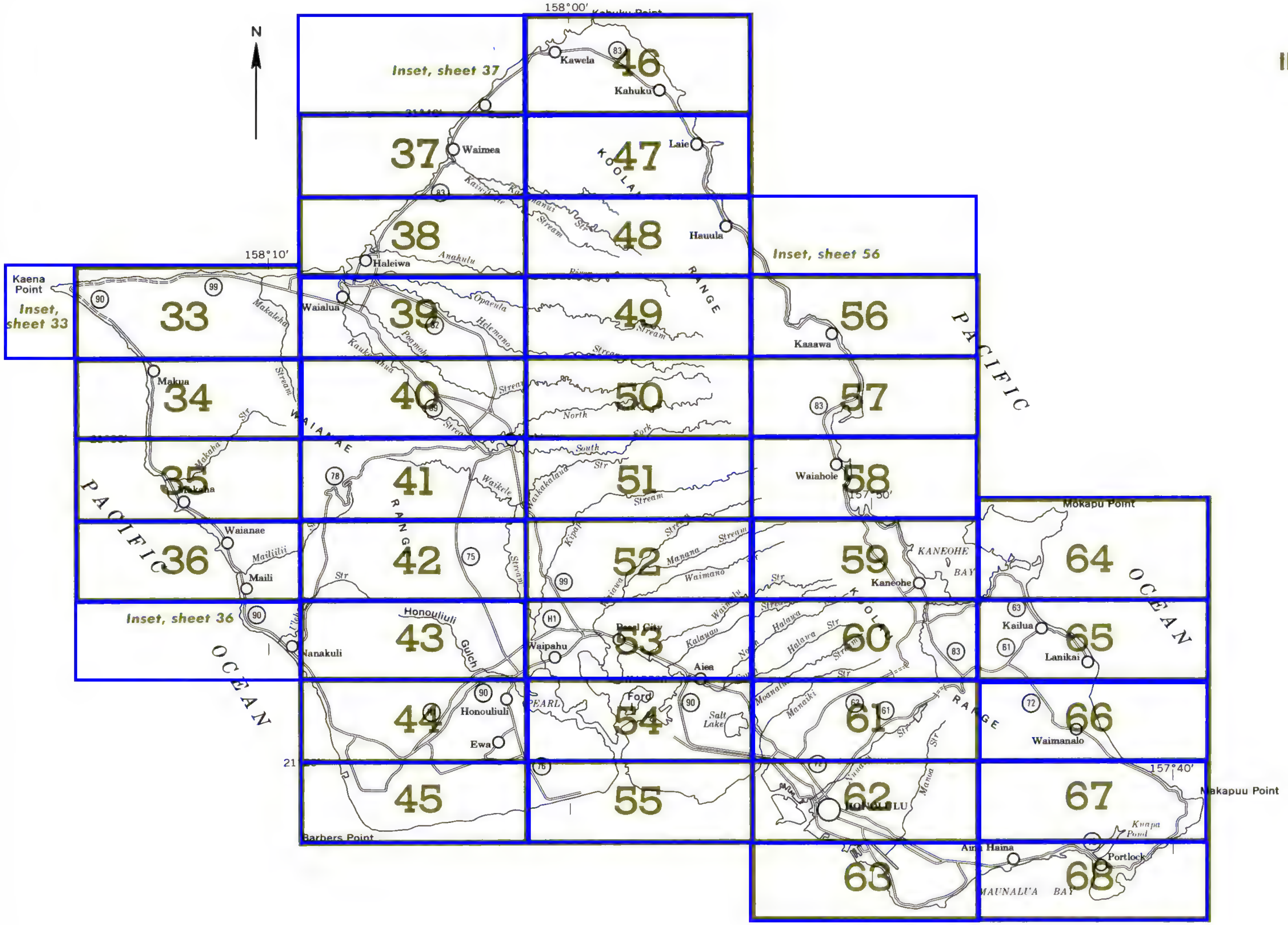
Scale 1:253,440

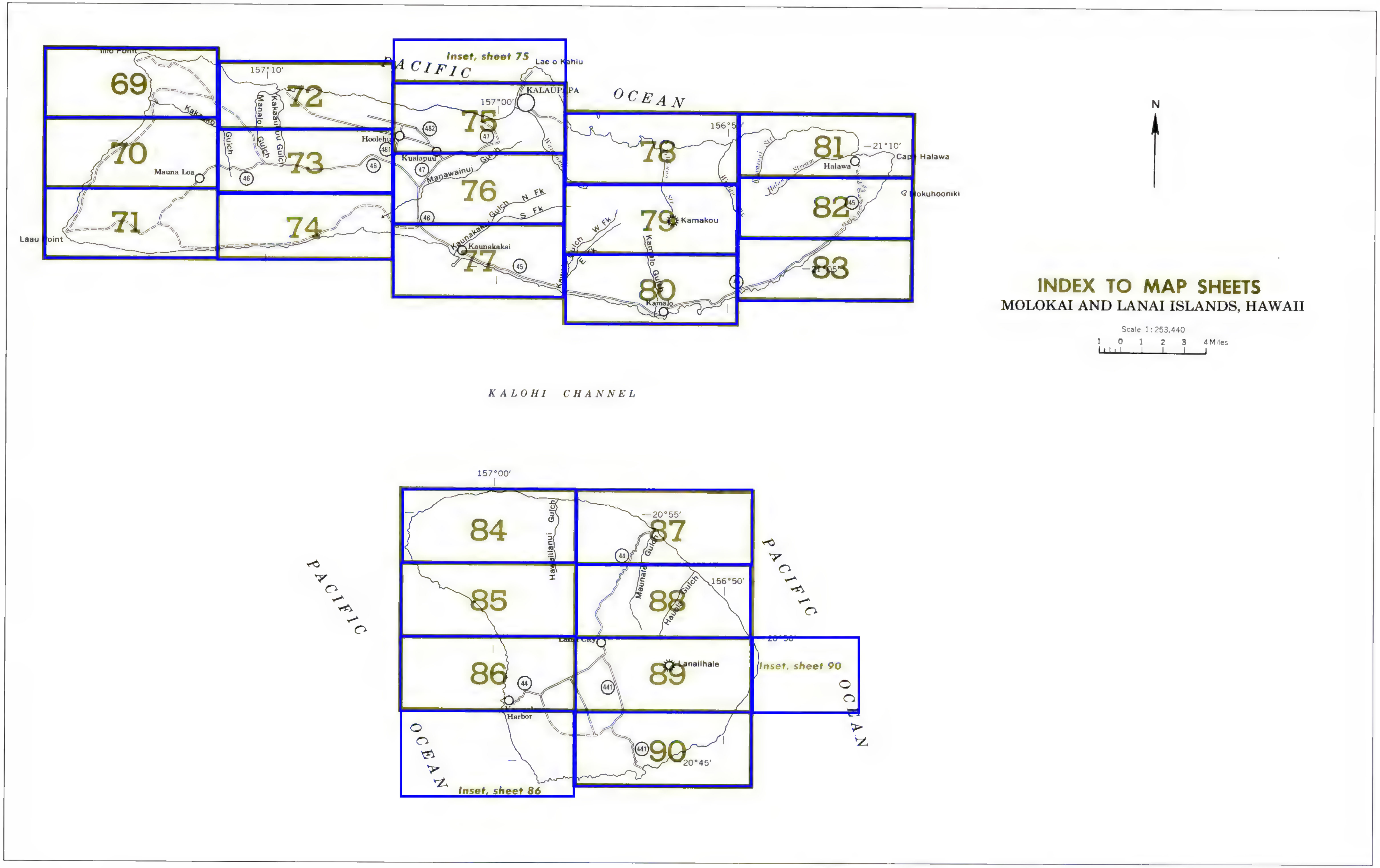
1 0 1 2 3 4 Miles

INDEX TO MAP SHEETS

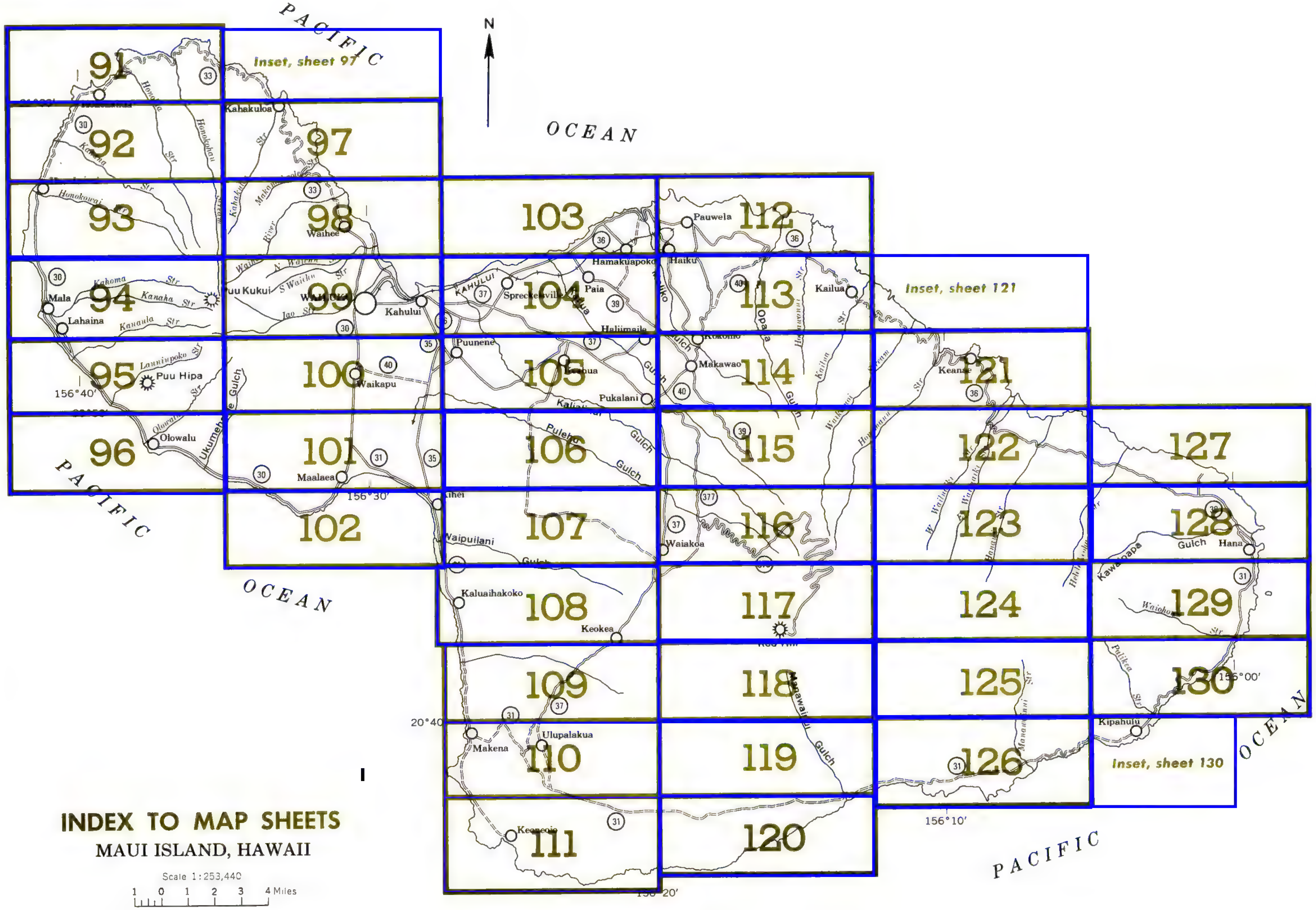
OAHU ISLAND, HAWAII

Scale 1:253,440





INDEX TO MAP SHEETS
MOLOKAI AND LANAI ISLANDS, HAWAII
Scale 1:253,440
1 0 1 2 3 4 Miles
N
PACIFIC OCEAN
KALOHI CHANNEL
Inset, sheet 75
Lae o Kahiu
KALAUPAPA
157°10′
157°00′
156°55′
21°10′
21°05′
Laau Point
Mauna Loa
Hoolehua
Kualapuu
Manawainui Gulch
Kaunakakai
Kamakou
Kamalo
Halawa
Cape Halawa
Mokuhooniki
69
70
71
72
73
74
75
76
77
78
79
80
81
82
83
157°00′
20°55′
156°50′
20°50′
20°45′
Hauola Gulch
Maunalei Gulch
Hawaiilanui Gulch
Lanai City
Lanaihale
Harbor
Inset, sheet 90
Inset, sheet 86
PACIFIC
PACIFIC
OCEAN
OCEAN
84
85
86
87
88
89
90



INDEX TO MAP SHEETS
MAUI ISLAND, HAWAII

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

ISLANDS OF KAUAI, OAHU, MAUI, MOLOKAI, AND LANAI, STATE OF HAWAII

UNIVERSITY OF HAWAII AGRICULTURAL EXPERIMENT STATION

SOIL LEGEND

The first capital letter is the initial one of the soil name. The next letter is a capital if the mapping unit is one of the low intensity or reconnaissance surveys, it is a small letter if the mapping unit is one of the high intensity survey. The last letter, a capital A, B, C, D, E, F, or G, indicates the slope. Most symbols without a slope letter are those of soils and land types that have a considerable range in slope. A final number, 2 or 3, in the symbol indicates that the soil is eroded or severely eroded. The small letter "r" precedes the symbols for soils of the reconnaissance survey.

HIGH AND MEDIUM INTENSITY

SYMBOL	NAME
AaB	Alae sandy loam, 3 to 7 percent slopes
AcA	Alae cobbly sandy loam, 0 to 3 percent slopes
AcB	Alae cobbly sandy loam, 3 to 7 percent slopes
AeB	Alaeloa silty clay, 3 to 7 percent slopes
AeC	Alaeloa silty clay, 7 to 15 percent slopes
AeE	Alaeloa silty clay, 15 to 35 percent slopes
EaA	Ewa silty clay loam, 0 to 3 percent slopes
EaB	Ewa silty clay loam, 3 to 6 percent slopes
EaC	Ewa silty clay loam, 6 to 12 percent slopes
EcA	Ewa cobbly silty clay loam, 0 to 3 percent slopes
EcB	Ewa cobbly silty clay loam, 3 to 7 percent slopes
EmA	Ewa silty clay loam, moderately shallow, 0 to 2 percent slopes
EmB	Ewa silty clay loam, moderately shallow, 2 to 6 percent slopes
EsA	Ewa silty clay, 0 to 3 percent slopes
EsB	Ewa silty clay, 3 to 7 percent slopes
EtB	Ewa cobbly silty clay, 3 to 7 percent slopes
EwA	Ewa stony silty clay, 0 to 2 percent slopes
EwB	Ewa stony silty clay, 2 to 6 percent slopes
EwC	Ewa stony silty clay, 6 to 12 percent slopes
Fd	Fill land
HaB	Haiku silty clay, 3 to 7 percent slopes
HaC	Haiku silty clay, 7 to 15 percent slopes
HbB	Haiku clay, 3 to 7 percent slopes
HbC	Haiku clay, 7 to 15 percent slopes
HcB	Haleiwa silty clay loam, 0 to 10 percent slopes
HdC	Haleiwa very stony silty clay loam, 0 to 15 percent slopes
HeA	Haleiwa silty clay, 0 to 2 percent slopes
HeB	Haleiwa silty clay, 2 to 6 percent slopes
HfB	Halii gravelly silty clay, 3 to 8 percent slopes
HfC	Halii gravelly silty clay, 8 to 15 percent slopes
HfD2	Halii gravelly silty clay, 15 to 25 percent slopes, eroded
HfE2	Halii gravelly silty clay, 25 to 40 percent slopes, eroded
HgB	Halimaile silty clay loam, 3 to 7 percent slopes
HgC	Halimaile silty clay loam, 7 to 15 percent slopes
HhB	Halimaile silty clay, 3 to 7 percent slopes
HhC	Halimaile silty clay, 7 to 15 percent slopes
HkC2	Halimaile gravelly silty clay, 7 to 15 percent slopes, eroded
HlB	Hamakuapoko silty clay, 3 to 7 percent slopes
HlC	Hamakuapoko silty clay, 7 to 15 percent slopes
HlC2	Hamakuapoko silty clay, 7 to 15 percent slopes, eroded
HmA	Hanalei silty clay loam, 0 to 2 percent slopes
HnA	Hanalei silty clay, 0 to 2 percent slopes
HnB	Hanalei silty clay, 2 to 6 percent slopes
HoB	Hanalei stony silty clay, 2 to 6 percent slopes
HpA	Hanalei peaty silty clay loam, 0 to 2 percent slopes
HrB	Hanalei silty clay, deep water table, 0 to 6 percent slopes
HsB	Hanamaulu silty clay, 3 to 8 percent slopes
HsC	Hanamaulu silty clay, 8 to 15 percent slopes
HsD	Hanamaulu silty clay, 15 to 25 percent slopes
HsE	Hanamaulu silty clay, 25 to 40 percent slopes
HtE	Hanamaulu stony silty clay, 10 to 35 percent slopes
HuE	Hanamaulu bouldery silty clay, 10 to 35 percent slopes
HvA	Holomua silt loam, 0 to 3 percent slopes
HvB	Holomua silt loam, 3 to 7 percent slopes
HvB3	Holomua silt loam, 3 to 7 percent slopes, severely eroded
HvC	Holomua silt loam, 7 to 15 percent slopes
HvC3	Holomua silt loam, 7 to 15 percent slopes, severely eroded
HwC	Honolua silty clay, 7 to 15 percent slopes
HwD	Honolua silty clay, 15 to 25 percent slopes
HxA	Honouliuli clay, 0 to 2 percent slopes
HxB	Honouliuli clay, 2 to 6 percent slopes

HIGH AND MEDIUM INTENSITY

SYMBOL	NAME
HyB3	Hoolehua silty clay loam, 3 to 10 percent slopes, severely eroded
HzA	Hoolehua silty clay, 0 to 3 percent slopes
HzB	Hoolehua silty clay, 3 to 7 percent slopes
HzC	Hoolehua silty clay, 7 to 15 percent slopes
HzE	Hoolehua silty clay, 15 to 35 percent slopes
IaA	Iao silty clay, 0 to 3 percent slopes
IaB	Iao silty clay, 3 to 7 percent slopes
IbB	Iao cobbly silty clay, 3 to 7 percent slopes
IbC	Iao cobbly silty clay, 7 to 15 percent slopes
IcB	Iao clay, 3 to 7 percent slopes
IcC	Iao clay, 7 to 15 percent slopes
IoB	Ioleau silty clay loam, 2 to 6 percent slopes
IoC	Ioleau silty clay loam, 6 to 12 percent slopes
IoD2	Ioleau silty clay loam, 12 to 20 percent slopes, eroded
IoE2	Ioleau silty clay loam, 20 to 35 percent slopes, eroded
JaC	Jaucas sand, 0 to 15 percent slopes
JcC	Jaucas sand, saline, 0 to 12 percent slopes
JfB	Jaucas loamy fine sand, 0 to 8 percent slopes
JkB	Jaucas loamy fine sand, dark variant, 0 to 8 percent slopes
KaB	Kaena clay, 2 to 6 percent slopes
KaC	Kaena clay, 6 to 12 percent slopes
KaeB	Kaena stony clay, 2 to 6 percent slopes
KaeC	Kaena stony clay, 6 to 12 percent slopes
KaeD	Kaena stony clay, 12 to 20 percent slopes
KanE	Kaena very stony clay, 10 to 35 percent slopes
KavB	Kaena clay, brown variant, 1 to 6 percent slopes
KavC	Kaena clay, brown variant, 6 to 12 percent slopes
KbB	Kahana silty clay, 3 to 7 percent slopes
KbC	Kahana silty clay, 7 to 15 percent slopes
KbD	Kahana silty clay, 15 to 25 percent slopes
KcB	Kalae silty clay, 2 to 7 percent slopes
KcC	Kalae silty clay, 7 to 15 percent slopes
KcC3	Kalae silty clay, 5 to 15 percent slopes, severely eroded
KcD3	Kalae silty clay, 15 to 25 percent slopes, severely eroded
KcE3	Kalae silty clay, 25 to 40 percent slopes, severely eroded
KdD	Kalapa silty clay, 8 to 20 percent slopes
KdE	Kalapa silty clay, 20 to 40 percent slopes
KdF	Kalapa silty clay, 40 to 70 percent slopes
Ke	Kalihi clay
Kf	Kaloko clay loam
Kfa	Kaloko clay
Kfb	Kaloko clay, noncalcareous variant
KgB	Kaneohe silty clay, 3 to 8 percent slopes
KgC	Kaneohe silty clay, 8 to 15 percent slopes
KhB	Kanepuu silty clay, 3 to 7 percent slopes
KhB2	Kanepuu silty clay, 3 to 7 percent slopes, eroded
KhC	Kanepuu silty clay, 7 to 15 percent slopes
KhC2	Kanepuu silty clay, 7 to 15 percent slopes, eroded
KkB	Kapaa silty clay, 3 to 8 percent slopes
KkC	Kapaa silty clay, 8 to 15 percent slopes
KkD	Kapaa silty clay, 15 to 25 percent slopes
KkE	Kapaa silty clay, 25 to 40 percent slopes
KlA	Kawaihapai clay loam, 0 to 2 percent slopes
KlB	Kawaihapai clay loam, 2 to 6 percent slopes
KlC	Kawaihapai clay loam, 6 to 15 percent slopes
KlaA	Kawaihapai stony clay loam, 0 to 2 percent slopes
KlaB	Kawaihapai stony clay loam, 2 to 6 percent slopes
KlbC	Kawaihapai very stony clay loam, 0 to 15 percent slopes
KlcB	Kawaihapai silty clay loam, 2 to 7 percent slopes
KmA	Keaau clay, 0 to 2 percent slopes
KmaB	Keaau stony clay, 2 to 6 percent slopes
KmbA	Keaau clay, saline, 0 to 2 percent slopes
KnB	Keahua silty clay loam, 3 to 7 percent slopes
KnC	Keahua silty clay loam, 7 to 15 percent slopes

HIGH AND MEDIUM INTENSITY

SYMBOL	NAME
KnaB	Keahua cobbly silty clay loam, 3 to 7 percent slopes
KnaC	Keahua cobbly silty clay loam, 7 to 15 percent slopes
KnaD	Keahua cobbly silty clay loam, 15 to 25 percent slopes
KnbD	Keahua very stony silty clay loam, 7 to 25 percent slopes
KncC	Keahua silty clay, 7 to 15 percent slopes
KnhC	Keahua cobbly silty clay, 7 to 15 percent slopes
KnsC	Keahua stony silty clay, 7 to 15 percent slopes
KoA	Kekaha silty clay, 0 to 2 percent slopes
KoB	Kekaha silty clay, 2 to 6 percent slopes
KobA	Kekaha clay, 0 to 2 percent slopes
KpB	Kemoo silty clay, 2 to 6 percent slopes
KpC	Kemoo silty clay, 6 to 12 percent slopes
KpD	Kemoo silty clay, 12 to 20 percent slopes
KpE	Kemoo silty clay, 20 to 35 percent slopes
KpF	Kemoo silty clay, 35 to 70 percent slopes
KrB	Koele silty clay loam, 3 to 7 percent slopes
KrC	Koele silty clay loam, 7 to 15 percent slopes
KrD	Koele silty clay loam, 15 to 25 percent slopes
KsB	Koko silt loam, 2 to 6 percent slopes
KsC	Koko silt loam, 6 to 12 percent slopes
KsD	Koko silt loam, 12 to 25 percent slopes
KtC	Kokokahi clay, 6 to 12 percent slopes
KuB	Kolekole silty clay loam, 1 to 6 percent slopes
KuC	Kolekole silty clay loam, 6 to 12 percent slopes
KuD	Kolekole silty clay loam, 12 to 25 percent slopes
KvB	Koloa stony silty clay, 3 to 8 percent slopes
KvC	Koloa stony silty clay, 8 to 15 percent slopes
KvD	Koloa stony silty clay, 15 to 25 percent slopes
Kw	Kolokolo clay loam
KxC	Kula loam, 4 to 12 percent slopes
KxD	Kula loam, 12 to 20 percent slopes
KxaD	Kula cobbly loam, 12 to 20 percent slopes
KxbE	Kula very rocky loam, 12 to 40 percent slopes
KyA	Kunia silty clay, 0 to 3 percent slopes
KyB	Kunia silty clay, 3 to 8 percent slopes
KyC	Kunia silty clay, 8 to 15 percent slopes
LaA	Lahaina silty clay, 0 to 3 percent slopes
LaB	Lahaina silty clay, 3 to 7 percent slopes
LaB3	Lahaina silty clay, 3 to 7 percent slopes, severely eroded
LaC	Lahaina silty clay, 7 to 15 percent slopes
LaC3	Lahaina silty clay, 7 to 15 percent slopes, severely eroded
LaD	Lahaina silty clay, 15 to 25 percent slopes
LaD3	Lahaina silty clay, 15 to 25 percent slopes, severely eroded
LaE3	Lahaina silty clay, 25 to 40 percent slopes, severely eroded
LcB	Lawai silty clay, 0 to 8 percent slopes
LcC	Lawai silty clay, 8 to 15 percent slopes
LcD	Lawai silty clay, 15 to 25 percent slopes
LeB	Leilehua silty clay, 2 to 6 percent slopes
LeC	Leilehua silty clay, 6 to 12 percent slopes
LhB	Lihue silty clay, 0 to 8 percent slopes
LhC	Lihue silty clay, 8 to 15 percent slopes
LhD	Lihue silty clay, 15 to 25 percent slopes
LhE2	Lihue silty clay, 25 to 40 percent slopes, eroded
LIB	Lihue gravelly silty clay, 0 to 8 percent slopes
LIC	Lihue gravelly silty clay, 8 to 15 percent slopes
LoB	Lolekaa silty clay, 3 to 8 percent slopes
LoC	Lolekaa silty clay, 8 to 15 percent slopes
LoD	Lolekaa silty clay, 15 to 25 percent slopes
LoE	Lolekaa silty clay, 25 to 40 percent slopes
LoF	Lolekaa silty clay, 40 to 70 percent slopes
LuA	Lualualei clay, 0 to 2 percent slopes
LuB	Lualualei clay, 2 to 6 percent slopes
LvA	Lualualei stony clay, 0 to 2 percent slopes
LvB	Lualualei stony clay, 2 to 6 percent slopes

HIGH AND MEDIUM INTENSITY

SYMBOL	NAME
MaC	Mahana silt loam, 6 to 12 percent slopes
MaD	Mahana silt loam, 12 to 20 percent slopes
MaD3	Mahana silt loam, 12 to 20 percent slopes, severely eroded
MaE	Mahana silt loam, 20 to 35 percent slopes
MaE3	Mahana silt loam, 20 to 35 percent slopes, severely eroded
McC2	Mahana silty clay loam, 6 to 12 percent slopes, eroded
McD2	Mahana silty clay loam, 12 to 20 percent slopes, eroded
McE2	Mahana silty clay loam, 20 to 35 percent slopes, eroded
MdB	Makalapa clay, 2 to 6 percent slopes
MdC	Makalapa clay, 6 to 12 percent slopes
MdD	Makalapa clay, 12 to 20 percent slopes
MeB	Makapili silty clay, 0 to 8 percent slopes
MeC	Makapili silty clay, 8 to 15 percent slopes
MeD	Makapili silty clay, 15 to 25 percent slopes
MeE	Makapili silty clay, 25 to 40 percent slopes
MfB	Makawao silty clay, 3 to 7 percent slopes
MfC	Makawao silty clay, 7 to 15 percent slopes
MgB	Makaweli silty clay loam, 0 to 6 percent slopes
MgC	Makaweli silty clay loam, 6 to 12 percent slopes
MgD	Makaweli silty clay loam, 12 to 20 percent slopes
MgE2	Makaweli silty clay loam, 20 to 35 percent slopes, eroded
MhB	Makaweli stony silty clay loam, 0 to 6 percent slopes
MhC	Makaweli stony silty clay loam, 6 to 12 percent slopes
MhD	Makaweli stony silty clay loam, 12 to 20 percent slopes
MhE	Makaweli stony silty clay loam, 20 to 35 percent slopes
MkA	Makiki clay loam, 0 to 2 percent slopes
MlA	Makiki stony clay loam, 0 to 3 percent slopes
MmA	Mala silty clay, 0 to 3 percent slopes
MmB	Mala silty clay, 3 to 7 percent slopes
MnC	Mamala stony silty clay loam, 0 to 12 percent slopes
MoB	Manana silty clay loam, 2 to 6 percent slopes
MoC	Manana silty clay loam, 6 to 12 percent slopes
MoD2	Manana silty clay loam, 12 to 25 percent slopes, eroded
MpB	Manana silty clay, 3 to 8 percent slopes
MpC	Manana silty clay, 8 to 15 percent slopes
MpD	Manana silty clay, 15 to 25 percent slopes
MpD2	Manana silty clay, 12 to 25 percent slopes, eroded
MpE	Manana silty clay, 25 to 40 percent slopes
Mr	Mokuleia fine sandy loam
Ms	Mokuleia loam
Mt	Mokuleia clay loam
Mta	Mokuleia clay loam, poorly drained variant
Mtb	Mokuleia clay
MuA	Molokai silty clay loam, 0 to 3 percent slopes
MuB	Molokai silty clay loam, 3 to 7 percent slopes
MuB3	Molokai silty clay loam, 3 to 7 percent slopes, severely eroded
MuC	Molokai silty clay loam, 7 to 15 percent slopes
MuC3	Molokai silty clay loam, 7 to 15 percent slopes, severely eroded
MuD	Molokai silty clay loam, 15 to 25 percent slopes
MvD3	Molokai silty clay loam, shallow variant, 15 to 25 percent slopes, severely eroded
NcC	Niu silty clay loam, 6 to 12 percent slopes
NcD	Niu silty clay loam, 12 to 20 percent slopes
NcD2	Niu silty clay loam, 6 to 20 percent slopes, eroded
NcE2	Niu silty clay loam, 20 to 35 percent slopes, eroded
Nh	Nohili clay
NnC	Nonopahu clay, 2 to 10 percent slopes
NoC	Nonopahu stony clay, 2 to 12 percent slopes
OlD	Oli loam, 12 to 20 percent slopes

HIGH AND MEDIUM INTENSITY

SYMBOL	NAME
PaC	Paaloa silty clay, 3 to 12 percent slopes
PbC	Paaloa clay, 2 to 12 percent slopes
PcB	Paia silty clay, 3 to 7 percent slopes
PcC	Paia silty clay, 7 to 15 percent slopes
PcC2	Paia silty clay, 7 to 15 percent slopes, eroded
PdA	Pakala clay loam, 0 to 2 percent slopes
PdC	Pakala clay loam, 2 to 10 percent slopes
PeB	Paumalu silty clay, 3 to 8 percent slopes
PeC	Paumalu silty clay, 8 to 15 percent slopes
PeD	Paumalu silty clay, 15 to 25 percent slopes
PeE	Paumalu silty clay, 25 to 40 percent slopes
PeF	Paumalu silty clay, 40 to 70 percent slopes
PfB	Pauwela clay, 3 to 7 percent slopes
PfC	Pauwela clay, 7 to 15 percent slopes
PfD	Pauwela clay, 15 to 25 percent slopes
Ph	Pearl Harbor clay
PkB	Pohakupu silty clay loam, 0 to 8 percent slopes
PkC	Pohakupu silty clay loam, 8 to 15 percent slopes
PlB	Pooku silty clay loam, 3 to 8 percent slopes
PlD	Pooku silty clay loam, 8 to 25 percent slopes
PmB	Pooku silty clay, 0 to 8 percent slopes
PmC	Pooku silty clay, 8 to 15 percent slopes
PmD	Pooku silty clay, 15 to 25 percent slopes
PmE	Pooku silty clay, 25 to 40 percent slopes
PnA	Puhi silty clay loam, 0 to 3 percent slopes
PnB	Puhi silty clay loam, 3 to 8 percent slopes
PnC	Puhi silty clay loam, 8 to 15 percent slopes
PnD	Puhi silty clay loam, 15 to 25 percent slopes
PnE	Puhi silty clay loam, 25 to 40 percent slopes
PoB	Pulehu sandy loam, 2 to 6 percent slopes
PoaB	Pulehu stony sandy loam, 0 to 7 percent slopes
PpA	Pulehu silt loam, 0 to 3 percent slopes
PpB	Pulehu silt loam, 3 to 7 percent slopes
PrA	Pulehu cobbly silt loam, 0 to 3 percent slopes
PrB	Pulehu cobbly silt loam, 3 to 7 percent slopes
PsA	Pulehu clay loam, 0 to 3 percent slopes
PtA	Pulehu cobbly clay loam, 0 to 3 percent slopes
PtB	Pulehu cobbly clay loam, 3 to 7 percent slopes
PuB	Pulehu stony clay loam, 2 to 6 percent slopes
PvC	Pulehu very stony clay loam, 0 to 12 percent slopes
PwC	Puu Opae silty clay loam, 8 to 15 percent slopes
PwD	Puu Opae silty clay loam, 15 to 25 percent slopes
PwE	Puu Opae silty clay loam, 25 to 40 percent slopes
UwB	Uwala silty clay loam, 2 to 7 percent slopes
UwC	Uwala silty clay loam, 7 to 15 percent slopes
UwC3	Uwala silty clay loam, 7 to 15 percent slopes, severely eroded
WaA	Wahiawa silty clay, 0 to 3 percent slopes
WaB	Wahiawa silty clay, 3 to 8 percent slopes
WaC	Wahiawa silty clay, 8 to 15 percent slopes
WaD2	Wahiawa silty clay, 15 to 25 percent slopes, eroded
WbB	Wahikuli silty clay, 3 to 7 percent slopes
WcB	Wahikuli stony silty clay, 3 to 7 percent slopes
WcC	Wahikuli stony silty clay, 7 to 15 percent slopes
WdB	Wahikuli very stony silty clay, 3 to 7 percent slopes
WeB	Waiakoa silty clay loam, 3 to 7 percent slopes
WeC	Waiakoa silty clay loam, 7 to 15 percent slopes
WfB	Waiakoa cobbly silty clay loam, 3 to 7 percent slopes
WgB	Waiakoa very stony silty clay loam, 3 to 7 percent slopes
WgC	Waiakoa very stony silty clay loam, 7 to 15 percent slopes
WhB	Waiakoa extremely stony silty clay loam, 3 to 7 percent slopes
WhC	Waiakoa extremely stony silty clay loam, 7 to 15 percent slopes
WkA	Waialua silty clay, 0 to 3 percent slopes
WkB	Waialua silty clay, 3 to 8 percent slopes
WlB	Waialua stony silty clay, 3 to 8 percent slopes
WlE	Waialua stony silty clay, 12 to 30 percent slopes
WmD	Waialua very stony silty clay, 12 to 20 percent slopes

HIGH AND MEDIUM INTENSITY

SYMBOL	NAME
WnB	Waialua clay, [illegible] to 6 percent slopes
WoA	Waihuna clay, 0 to 3 percent slopes
WoB	Waihuna clay, 3 to 7 percent slopes
Wo[illegible]	Waihuna clay, 7 to 15 percent slopes
Wo[illegible]	Waihuna clay, 15 to 25 percent slopes
W[illegible]B	Waihuna gravelly clay, 3 to 7 percent slopes
WpB	Waikane silty clay, 3 to 8 percent slopes
WpC	Waikane silty clay, 8 to 15 percent slopes
WpE	Waikane silty clay, 25 to 40 percent slopes
WpF	Waikane silty clay, 40 to 70 percent slopes
WpF2	Waikane silty clay, 40 to 70 percent slopes, eroded
WpaF	Waikane stony silty clay, 15 to 30 percent slopes
WrA	Waikapu silty clay loam, 0 to 3 percent slopes
WrB	Waikapu silty clay loam, 3 to 7 percent slopes
WrB3	Waikapu silty clay loam, 3 to 7 percent slopes, severely eroded
WrC3	Waikapu silty clay loam, 7 to 15 percent slopes, severely eroded
Ws	Waikomo stony silty clay
Wt	Waikomo very rocky silty clay
Wu	Waikomo extremely rocky silty clay
WvB	Wailuku silty clay, 3 to 7 percent slopes
WvC	Wailuku silty clay, 7 to 15 percent slopes
WwC	Wailuku cobbly silty clay, 7 to 15 percent slopes
WxB	Wainee very stony silty clay, 3 to 7 percent slopes
WxC	Wainee very stony silty clay, 7 to 15 percent slopes
WyB	Wainee extremely stony silty clay, 3 to 7 percent slopes
WyC	Wainee extremely stony silty clay, 7 to 15 percent slopes
WzA	Waipahu silty clay, 0 to 2 percent slopes
WzB	Waipahu silty clay, 2 to 6 percent slopes
WzC	Waipahu silty clay, 6 to 12 percent slopes

LOW INTENSITY

SYMBOL	NAME
ALE3	Alaeloa silty clay, 15 to 35 percent slopes, severely eroded
ALF	Alaeloa silty clay, 40 to 70 percent slopes
AME3	Alaeloa stony silty clay, 15 to 35 percent slopes, severely eroded
ANE	Alaeloa stony silty clay, overwash, 15 to 35 percent slopes
BL	Badland
BM	Badland-Mahana complex
BS	Beaches
BW	Blown-out land
CO	Colluvial land
CR	Coral outcrop
DL	Dune land
FL	Fill land, mixed
GL	Gullied land
HID	Halawa silty clay, 3 to 25 percent slopes
HID3	Halawa silty clay, 3 to 25 percent slopes, severely eroded
HJE	Halawa silt loam, 20 to 35 percent slopes
HJF2	Halawa silt loam, 35 to 70 percent slopes, eroded
HKLD	Hana very stony silty clay loam, 3 to 25 percent slopes
HKMD	Hana extremely stony silty clay loam, 3 to 25 percent slopes
HKNC	Hana silty clay loam, moderately deep variant, 3 to 15 percent slopes

SOIL LEGEND

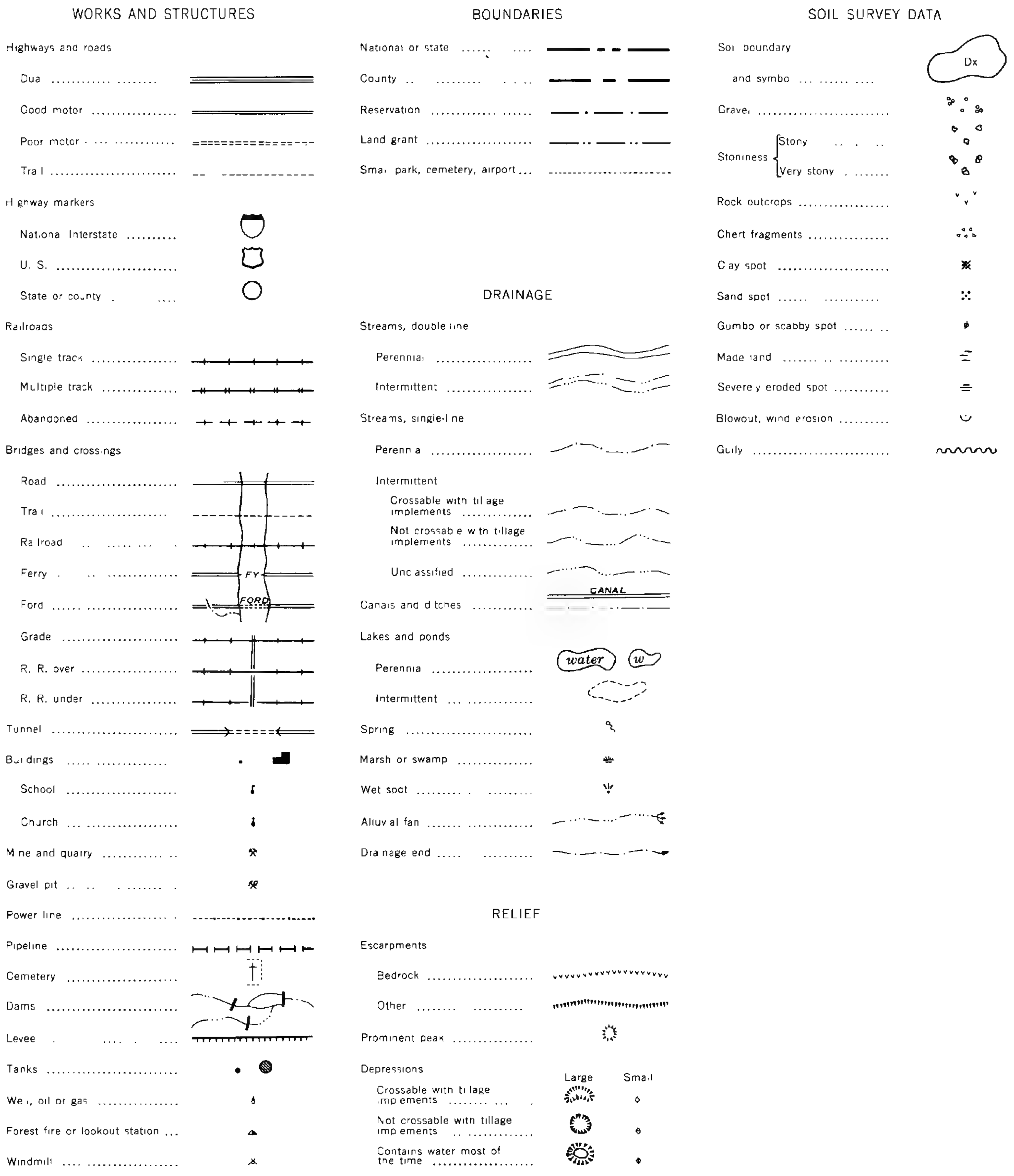
LOW INTENSITY

SYMBOL	NAME
HKOC	Hana extremely stony silty clay loam, moderately deep variant, 3 to 15 percent slopes
HLMG	Helemano silty clay, 30 to 90 percent slopes
HMMF	Hihimanu silty clay loam, 40 to 70 percent slopes
HNUD	Hulua gravelly silty clay loam, 3 to 25 percent slopes
HNUF	Hulua gravelly silty clay loam, 25 to 70 percent slopes
ISD	Io silt loam, 7 to 25 percent slopes
JL	Jaucas-Blown-out land complex
KASD	Kahanui silty clay, 3 to 20 percent slopes
KATD	Kahanui gravelly silty clay, 3 to 20 percent slopes
KBD	Kailua silty clay, 3 to 25 percent slopes
KCXD	Kaimu extremely stony peat, 7 to 25 percent slopes
KDIE	Kaipoioi loam, 7 to 40 percent slopes
KDVE	Kaipoioi very rocky loam, 7 to 40 percent slopes
KEHF	Kalapa very rocky silty clay, 40 to 70 percent slopes
KFID	Kalaupapa very rocky silty clay loam, 3 to 25 percent slopes
KGKC	Kamaole very stony silt loam, 3 to 15 percent slopes
KGLC	Kamaole extremely stony silt loam, 3 to 15 percent slopes
KHMC	Kaneohe silty clay loam, 5 to 15 percent slopes
KHME	Kaneohe silty clay loam, 15 to 30 percent slopes
KHMF	Kaneohe silty clay loam, 30 to 65 percent slopes
KHOF	Kaneohe silty clay, 30 to 65 percent slopes
KIG	Kapaa silty clay, 40 to 100 percent slopes
KKTC	Kapuhikani extremely stony clay, 3 to 15 percent slopes
KLUD	Kaupo very stony silty clay loam, 3 to 25 percent slopes
KLVD	Kaupo extremely stony silty clay, 3 to 25 percent slopes
KMW	Kealia silt loam
KNXD	Keawakapu extremely stony silty clay loam, 3 to 25 percent slopes
KOYE	Kekaha extremely stony silty clay loam, 0 to 35 percent slopes
KPZ	Kemoo-Badland complex
KRL	Koele-Badland complex
KRX	Koele rocky complex
KSKE	Kokee silty clay loam, 0 to 35 percent slopes
KSKF	Kokee silty clay loam, 35 to 70 percent slopes
KTKE	Kokokahi very stony clay, 0 to 35 percent slopes
KUL	Kolokolo extremely stony clay loam
KVSB	Koolau silty clay, 0 to 8 percent slopes
KVSE	Koolau silty clay, 8 to 30 percent slopes
KZC	Kunuweia very gravelly clay loam, 0 to 15 percent slopes
LME	Laumaia loam, 7 to 40 percent slopes
LMF	Laumaia loam, 40 to 70 percent slopes
LNE	Laumaia extremely stony loam, 7 to 40 percent slopes
LPE	Lualualei extremely stony clay, 3 to 35 percent slopes
MBL	Manana-Badland complex
MID	Makaalae silty clay, 7 to 25 percent slopes
MJD	Makaalae extremely stony silty clay, 7 to 25 percent slopes
MWE	Makaalae clay, 7 to 40 percent slopes
MXC	Makena loam, stony complex, 3 to 15 percent slopes
MYD	Malama extremely stony muck, 3 to 25 percent slopes
MZ	Marsh
NAC	Naiwa silty clay loam, 3 to 20 percent slopes
NAC3	Naiwa silty clay loam, 7 to 15 percent slopes, severely eroded
NLE	Niulii silty clay loam, 7 to 30 percent slopes
NME	Niulii silty clay loam, medium textured variant, 7 to 30 percent slopes
OAD	Oanapuka very stony silt loam, 7 to 25 percent slopes
OED	Oanapuka extremely stony silt loam, 7 to 25 percent slopes
OFC	Oelo silty clay, 3 to 15 percent slopes
OMB	Oli silt loam, 3 to 10 percent slopes
OME	Oli silt loam, 10 to 30 percent slopes
OMF	Oli silt loam, 30 to 70 percent slopes
ONC	Olinda loam, 4 to 12 percent slopes
OND	Olinda loam, 12 to 20 percent slopes
ONE	Olinda loam, 20 to 40 percent slopes
OOE	Olokui silty clay loam, 3 to 30 percent slopes
OPD	Opihikao extremely rocky muck, 3 to 25 percent slopes
PGE	Paaiki loam, 6 to 35 percent slopes
PGF	Paaiki loam, 35 to 70 percent slopes
PHXC	Pakaia extremely stony sandy clay loam, 0 to 12 percent slopes
PID	Pamoa silty clay, 5 to 20 percent slopes
PID2	Pamoa silty clay, 5 to 20 percent slopes, eroded
PJD2	Pamoa stony silty clay, 5 to 20 percent slopes, eroded
PXD	Pane silt loam, 7 to 25 percent slopes
PYD	Papaa clay, 6 to 20 percent slopes
PYE	Papaa clay, 20 to 35 percent slopes
PYF	Papaa clay, 35 to 70 percent slopes
PZ	Paumalu-Badland complex
PZUE	Puuone sand, 7 to 30 percent slopes
PZVE	Puu Pa very stony silt loam, 7 to 40 percent slopes
TAE	Tantalus silt loam, 15 to 40 percent slopes
TAF	Tantalus silt loam, 40 to 70 percent slopes
TCC	Tantalus silty clay loam, 8 to 15 percent slopes
TCE	Tantalus silty clay loam, 15 to 40 percent slopes
TR	Tropaquepts
ULD	Ulupalakua silt loam, 7 to 25 percent slopes
UME	Uma loamy coarse sand, 15 to 40 percent slopes
UMF	Uma loamy coarse sand, 40 to 70 percent slopes
URD	Uma rocky loamy coarse sand, 7 to 25 percent slopes
WID2	Waiakoa extremely stony silty clay loam, 3 to 25 percent slopes, eroded
WLF	Waiawa extremely rocky clay, 30 to 80 percent slopes

RECONNAISSANCE

SYMBOL	NAME
rAAE	Alakai mucky peat, 0 to 30 percent slopes
rAMD	Amalu peaty silty clay, 3 to 20 percent slopes
rAOD	Amalu Olokui association, 3 to 20 percent slopes
rCI	Cinder land
rHOD	Honomanu silty clay, 5 to 25 percent slopes
rHR	Honomanu-Amalu association
rHT	Hydrandepts-Tropaquods association
rLW	Lava flows, Aa
rRH	Riverwash
rRK	Rock land
rRO	Rock outcrop
rRR	Rough broken land
rRS	Rough broken and stony land
rRT	Rough mountainous land
rRU	Rubble land
rSL	Sandy alluvial land
rSM	Stony alluvial land
rSN	Stony blown-out land
rSO	Stony colluvial land
rST	Stony land
rSY	Stony steep land
rTO	Tropaquods
rTP	Tropohumults-Dystrandepts association
rVS	Very stony land
rVT2	Very stony land, eroded
rWAF	Waialeale mucky silty clay loam, 30 to 70 percent slopes

CONVENTIONAL SIGNS



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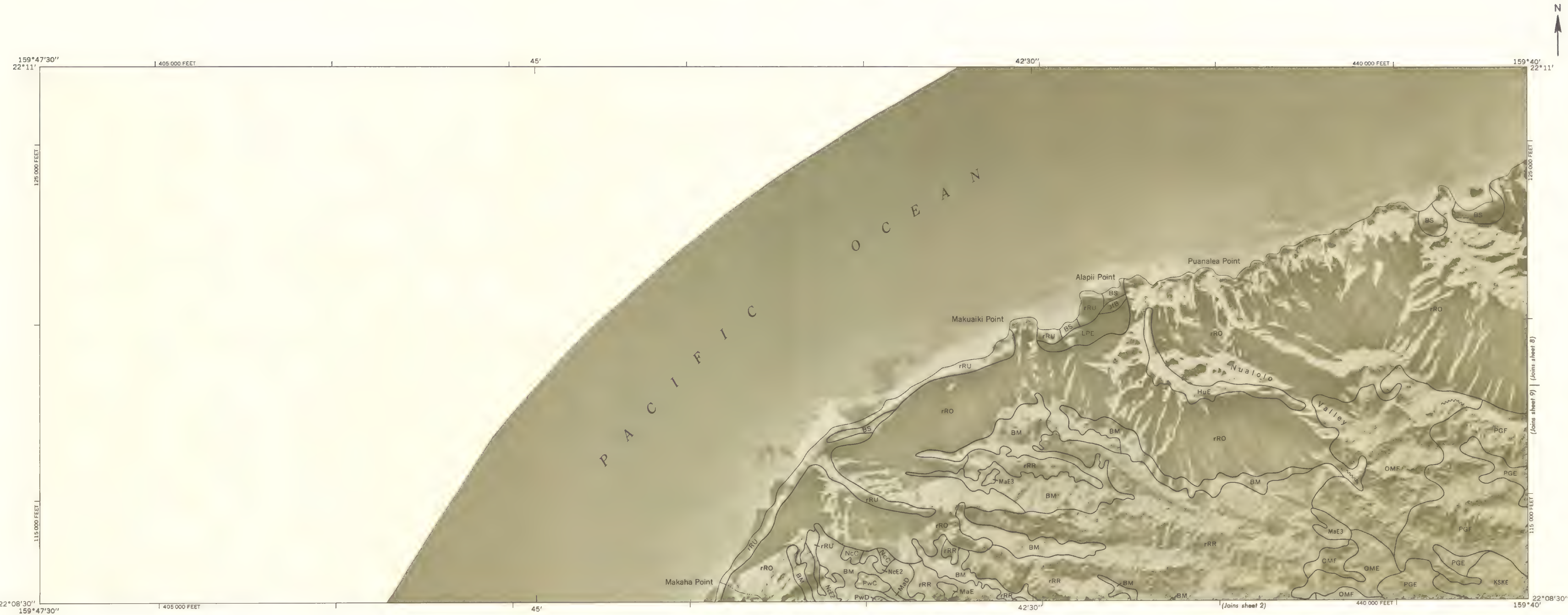


This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

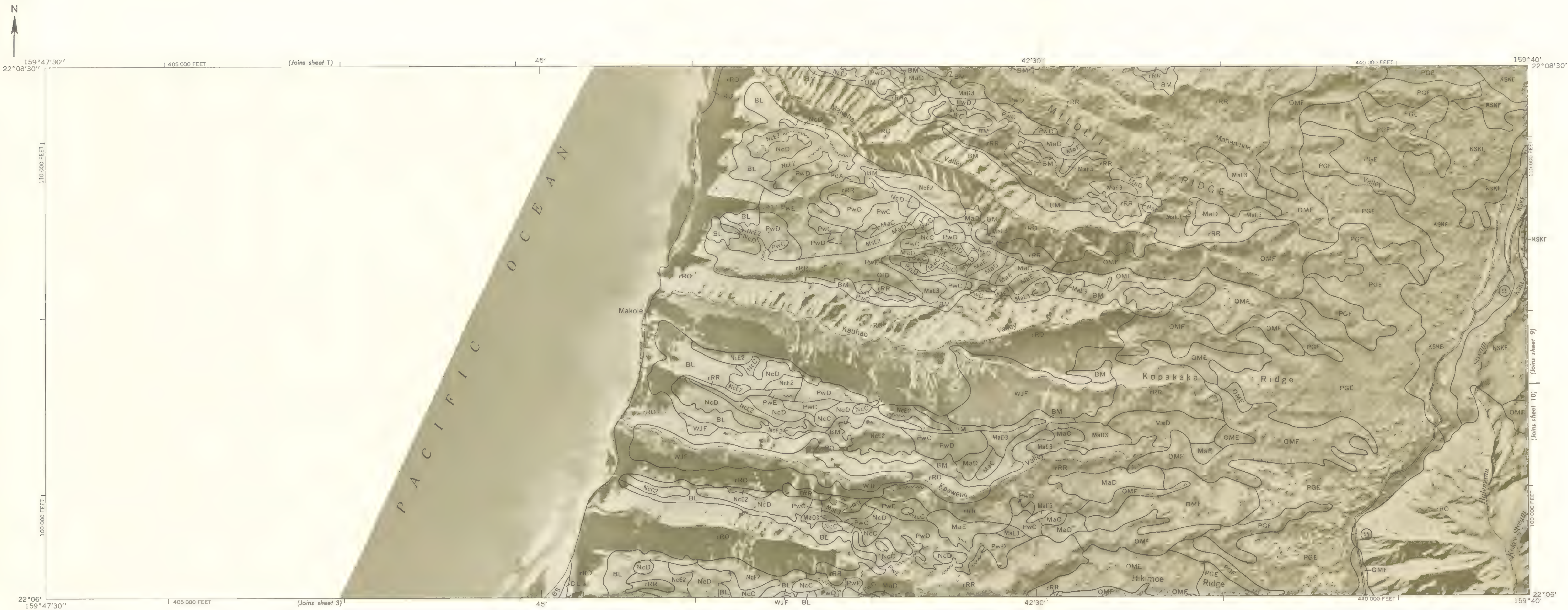
KAUAI ISLAND, HAWAII NO. 1

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 4. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet



Scale 1:24 000

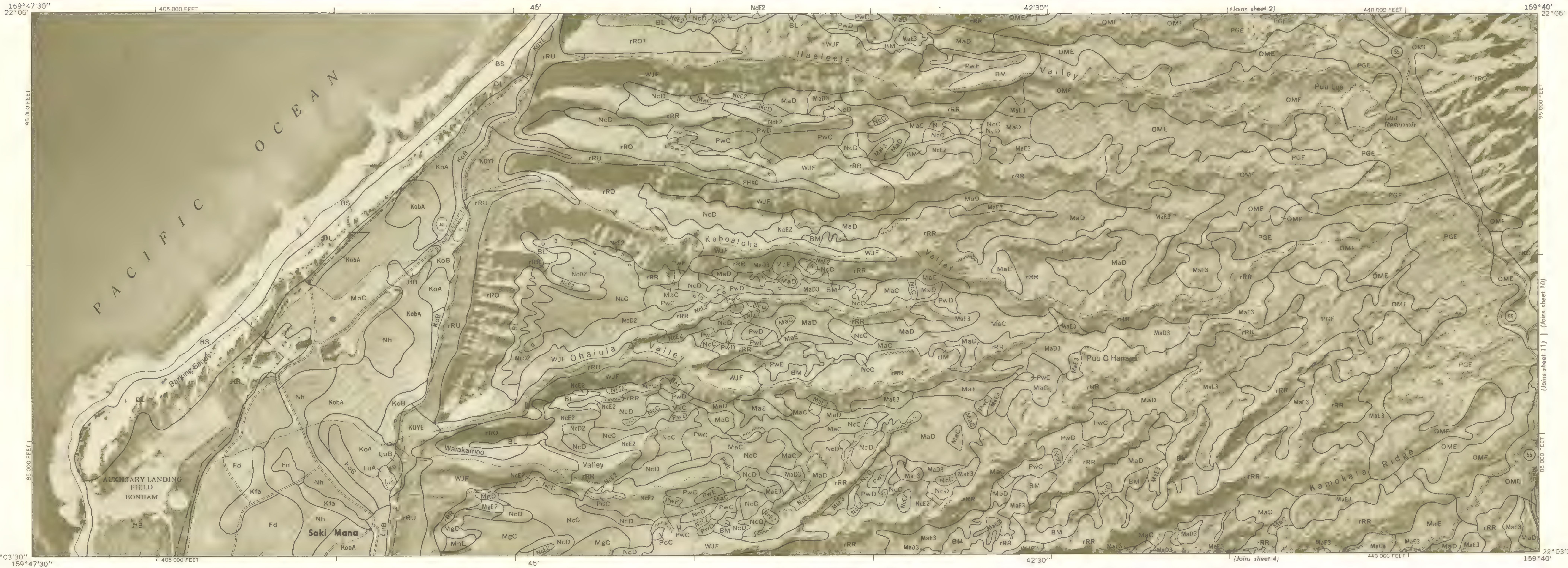
1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 4. Old Hawaiian datum.

KAUAI ISLAND, HAWAII NO. 2

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.



Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 4. Old Hawaiian datum.

Scale 1:24 000

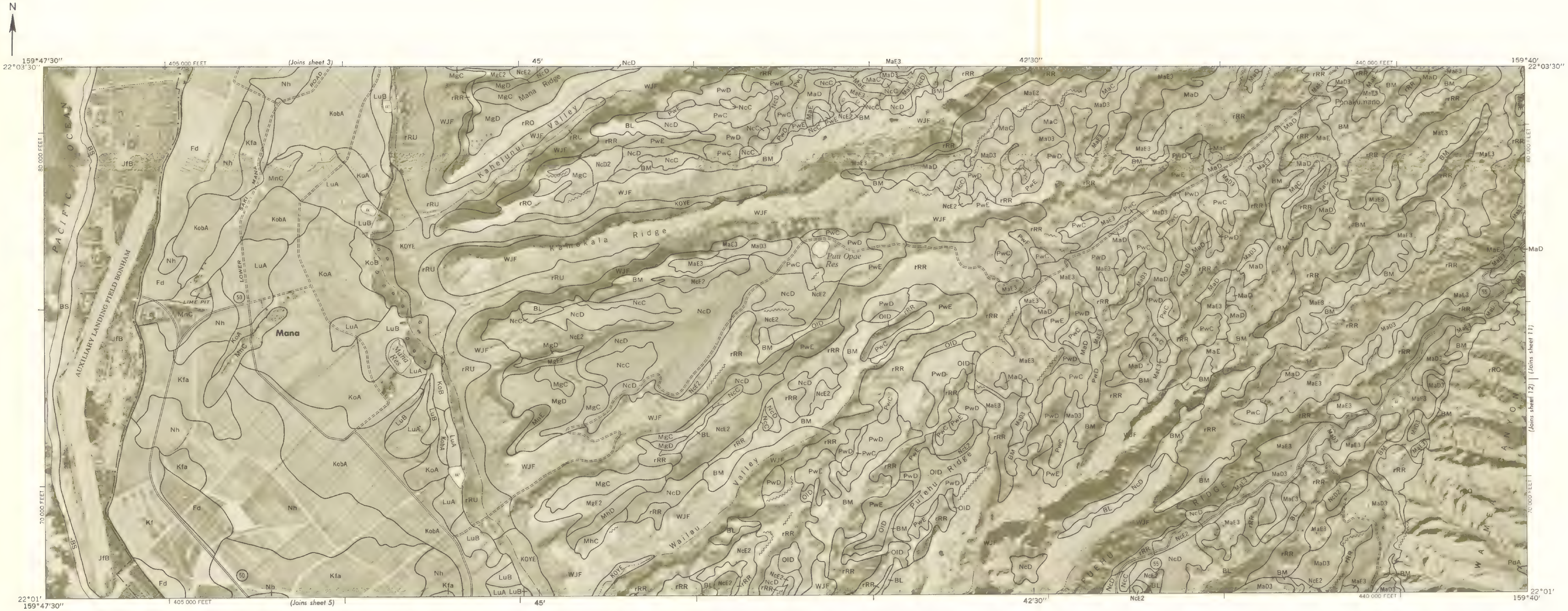
1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

4

KAUAI ISLAND, HAWAII — SHEET NUMBER 4



Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 4. Old Hawaiian datum.

KAUAI ISLAND, HAWAII NO. 4

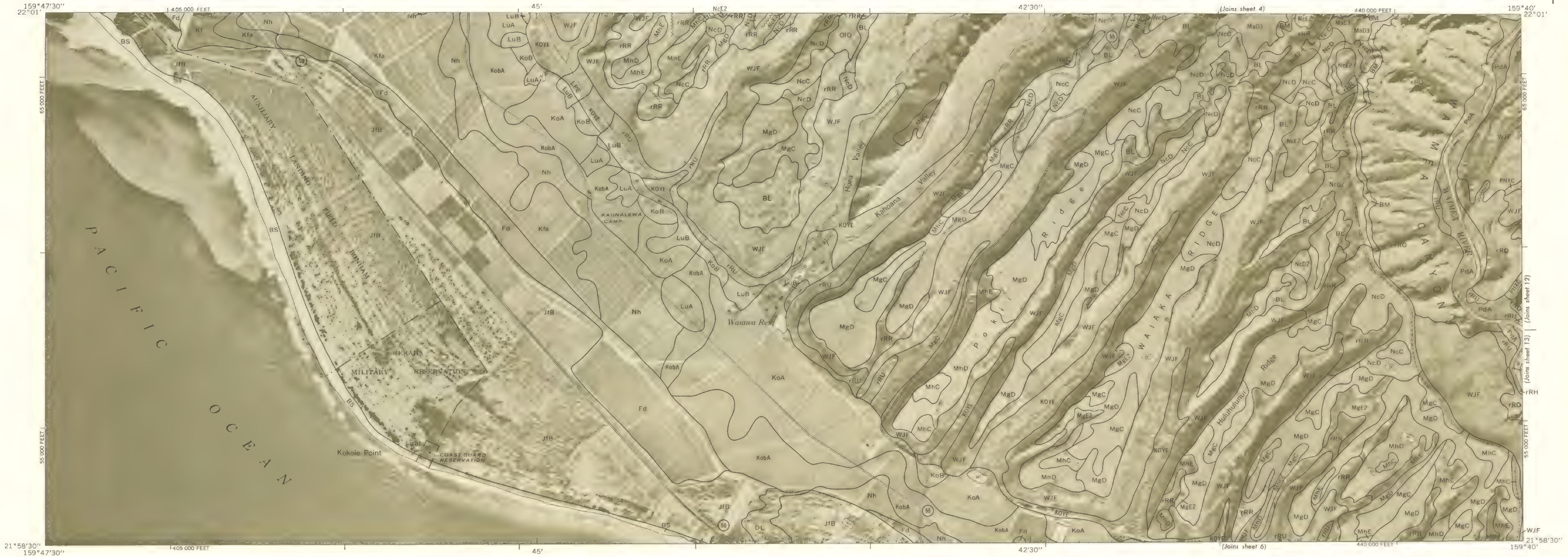
This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

KAUAI ISLAND, HAWAII — SHEET NUMBER 5

5

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

KAUAI ISLAND, HAWAII NO. 5



Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 4. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

KAUAI ISLAND, HAWAII — SHEET NUMBER 6

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 4. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

KAUAI ISLAND, HAWAII NO. 6

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

7

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 4. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

KAUAI ISLAND, HAWAII NO. 7

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

KAUAI ISLAND, HAWAII — SHEET NUMBER 8

N

159°40′ 445 000 FEET (Joins sheet 7) 37′30″ 35′ KUL 485 000 FEET 159°32′30″
22°12′ 22°12′

(Joins sheet 1) (Joins sheet 17)
130 000 FEET 120 000 FEET

22°09′30″ 22°09′30″
159°40′ 445 000 FEET (Joins sheet 9) 37′30″ 35′ 485 000 FEET 159°32′30″

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 4. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

KAUAI ISLAND, HAWAII NO. 8

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

KAUAI ISLAND, HAWAII NO. 9

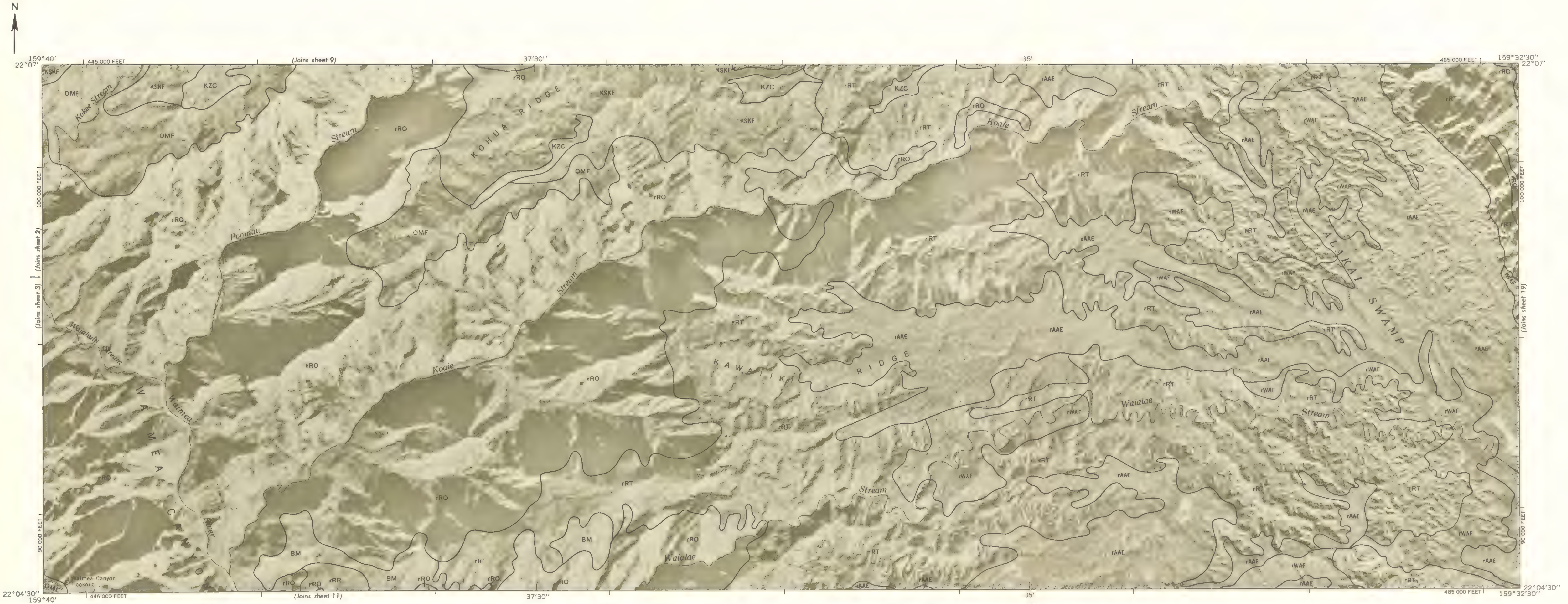
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 4. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

KAUAI ISLAND, HAWAII — SHEET NUMBER 10



Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 4. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

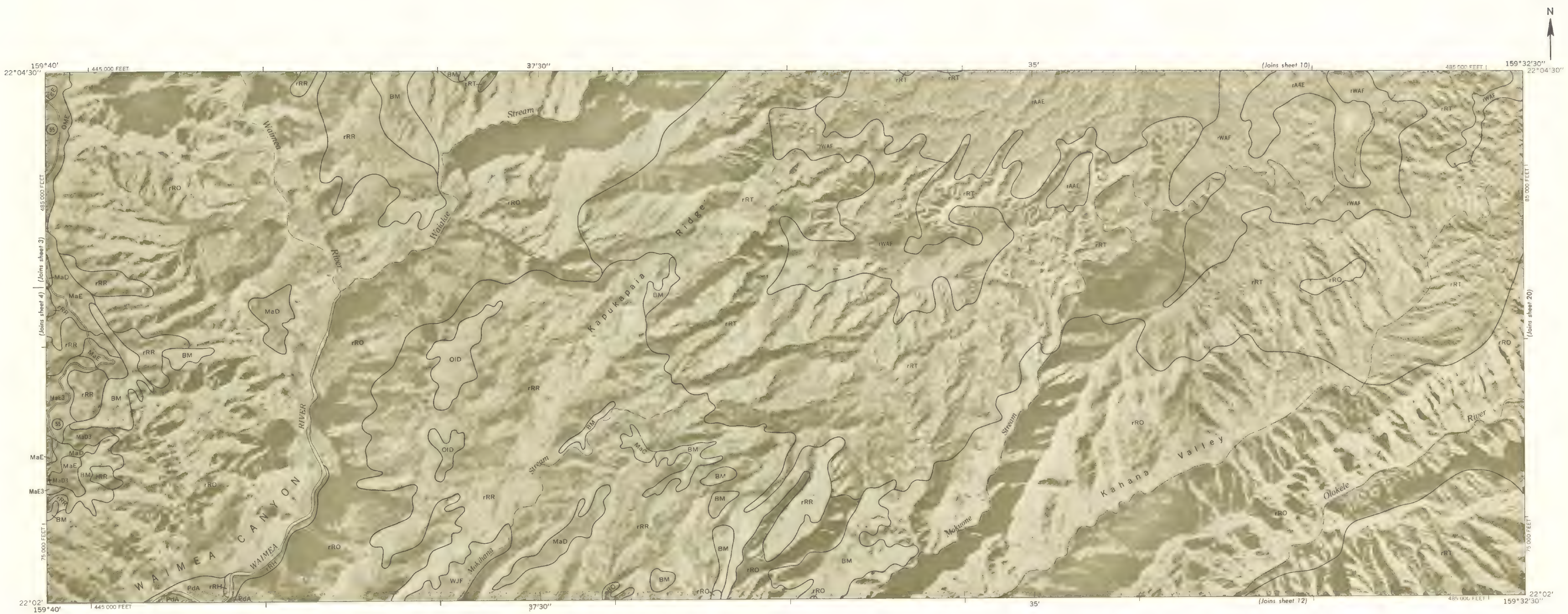
KAUAI ISLAND, HAWAII NO. 10

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

11

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station

KAUAI ISLAND, HAWAII NO. 11



Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 4. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

N

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 4. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

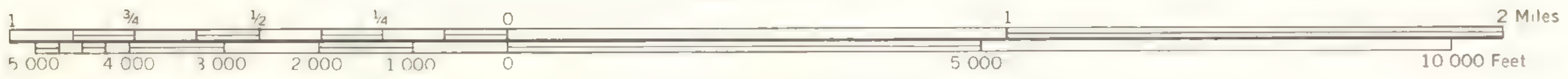
KAUAI ISLAND, HAWAII NO. 12

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

13

KAUAI ISLAND, HAWAII NO. 13

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 4. Old Hawaiian datum.



KAUAI ISLAND, HAWAII — SHEET NUMBER 14

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 4. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

KAUAI ISLAND, HAWAII NO. 14

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

KAUAI ISLAND, HAWAII NO. 15

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 4. Old Hawaiian datum.

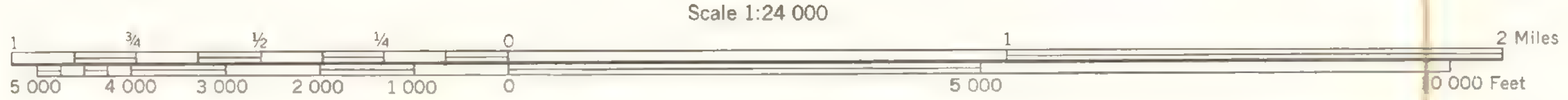
Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

KAUAI ISLAND, HAWAII — SHEET NUMBER 16

Scale 1:24 000



Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 4. Old Hawaiian datum.

KAUAI ISLAND, HAWAII NO. 16

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station

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KAUAI ISLAND, HAWAII NO. 17

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 4. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

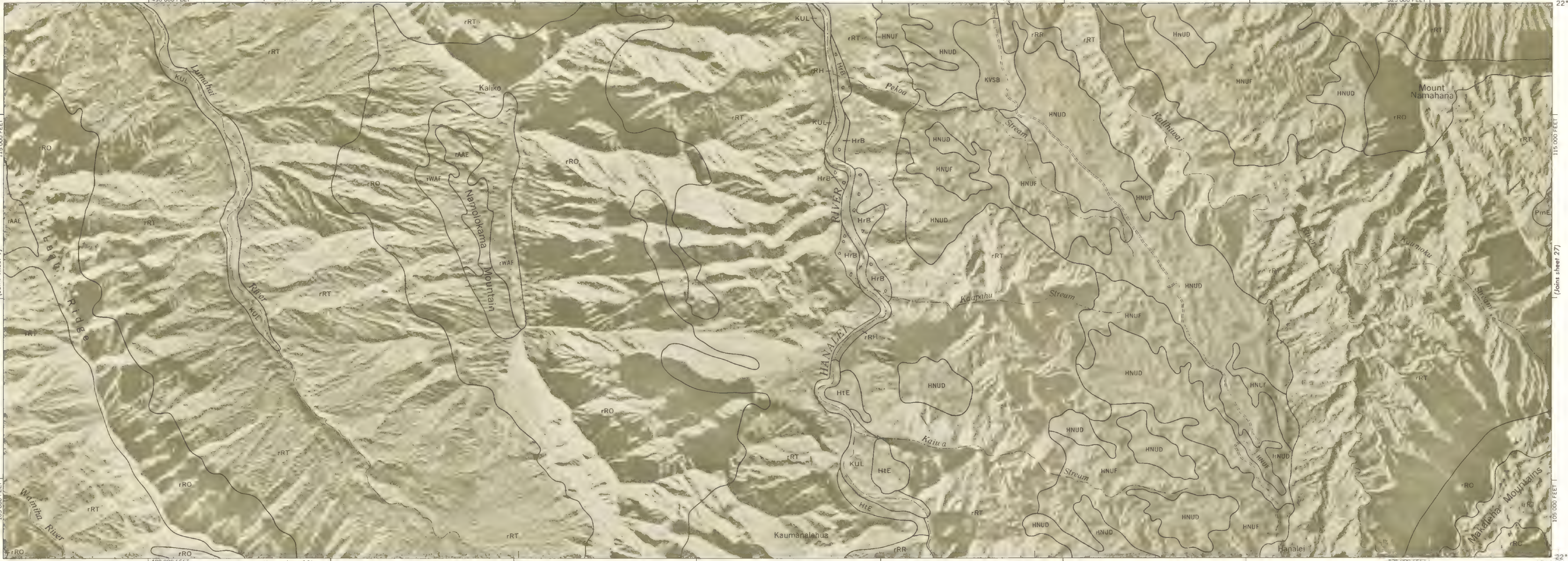
18

KAUAI ISLAND, HAWAII — SHEET NUMBER 18

N

159°32'30" | 490 000 FEET | (Joins sheet 17) | 30' | rRT | 27'30" | 525 000 FEET | 159°25'

22°09'30"



(Joins sheet 9)

(Joins sheet 27)

115 000 FEET

105 000 FEET

22°07'

159°32'30" | 490 000 FEET | (Joins sheet 19) | 30' | 27'30" | 525 000 FEET | 159°25'

KAUAI ISLAND, HAWAII NO. 18

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 4. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

N

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

KAUAI ISLAND, HAWAII NO. 19

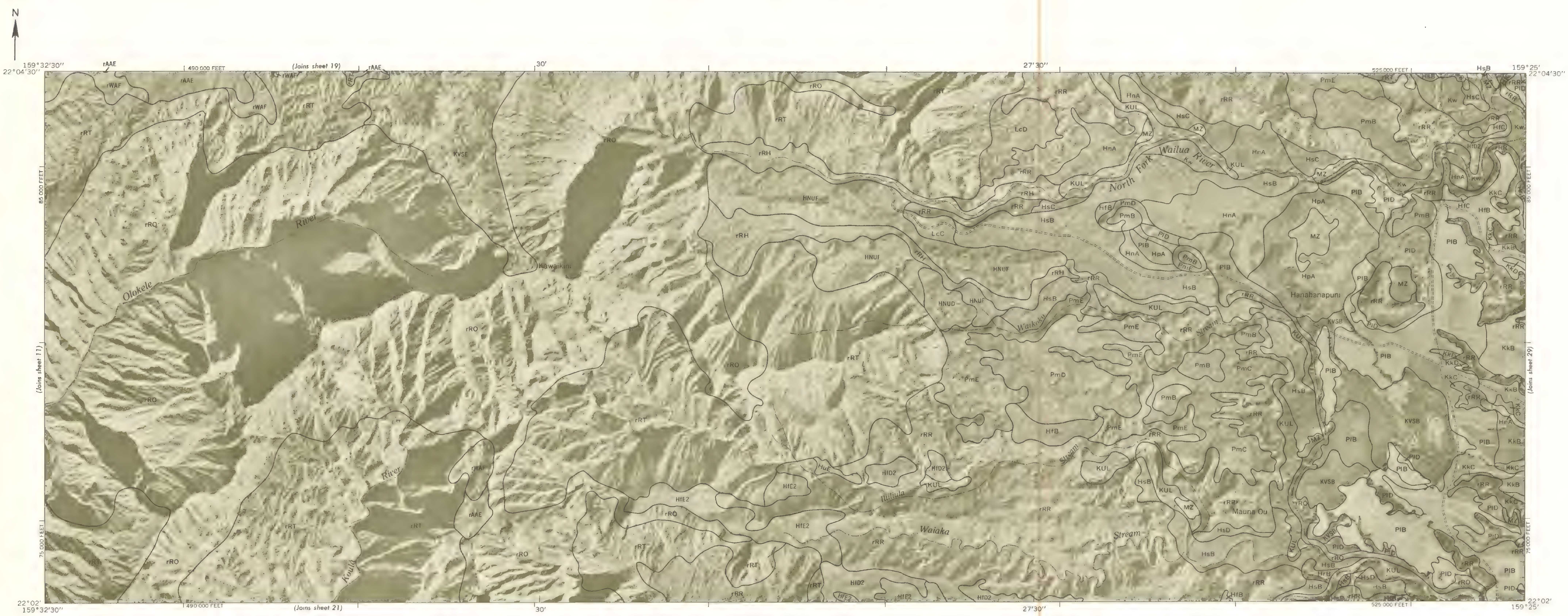
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 4. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

KAUAI ISLAND, HAWAII — SHEET NUMBER 20



Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 4. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

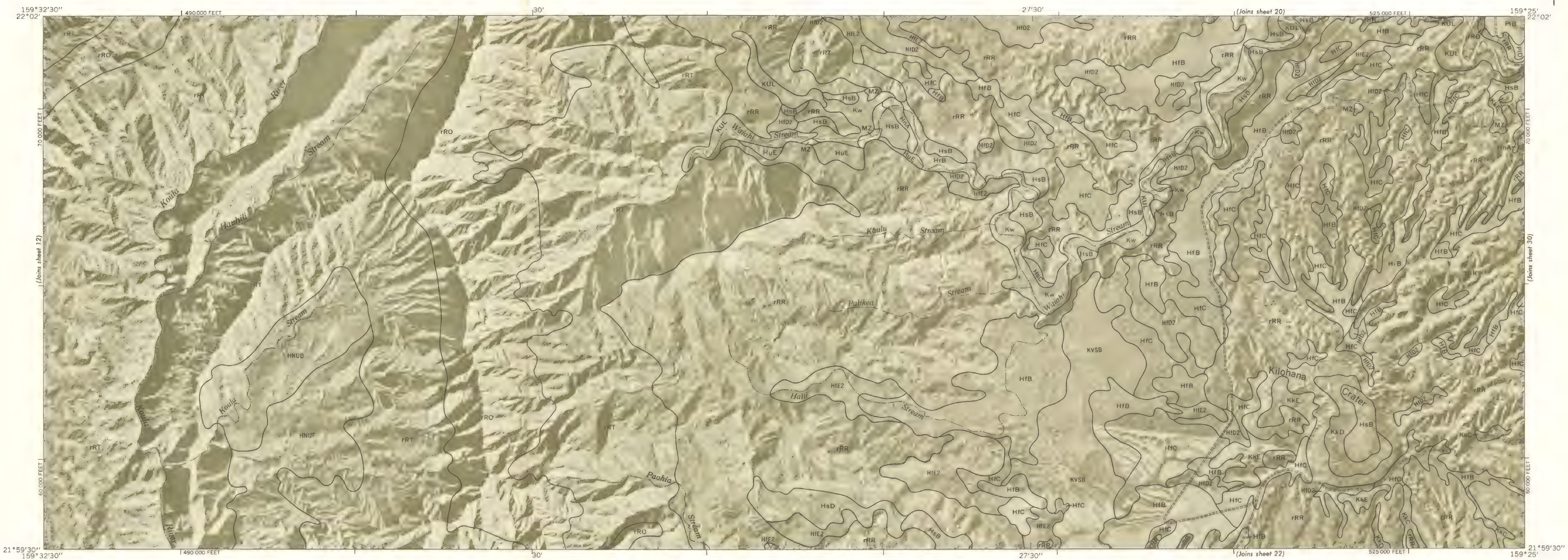
5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

KAUAI ISLAND, HAWAII NO. 20

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

KAUAI ISLAND, HAWAII NO. 21



Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 4. Old Hawaiian datum.

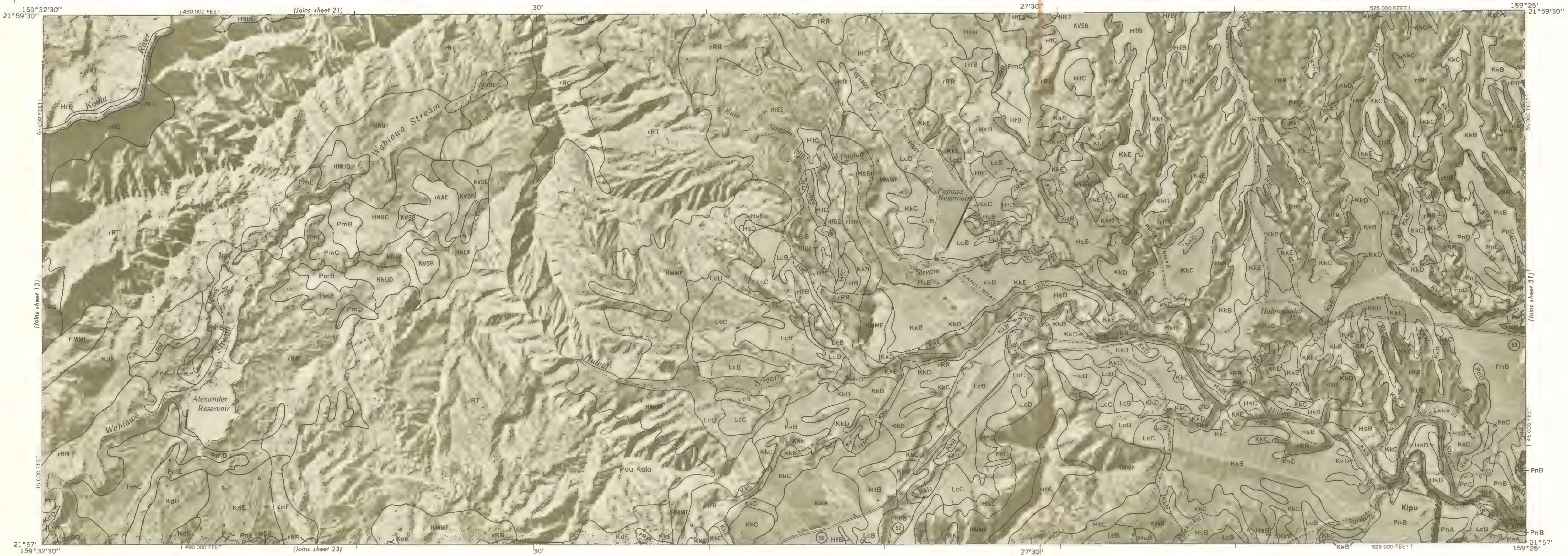
Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

(22)

KAUAI ISLAND, HAWAII — SHEET NUMBER 22



Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

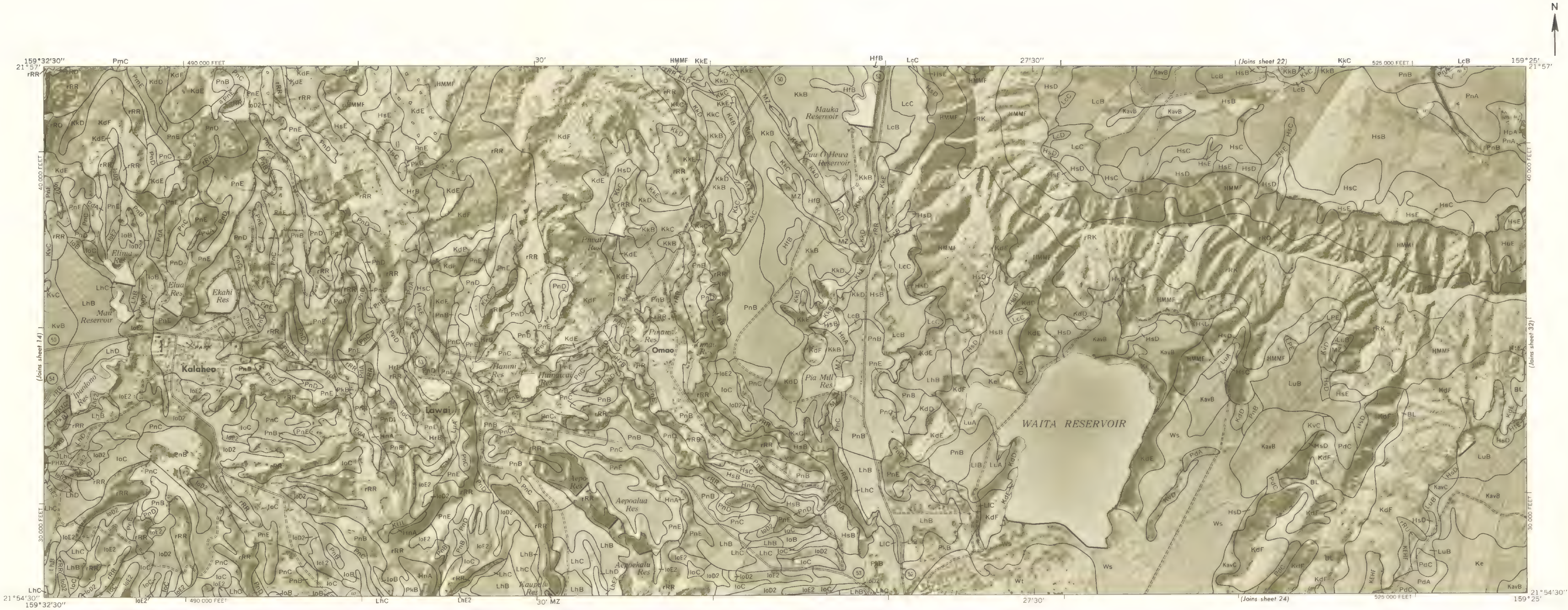
5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 4. Old Hawaiian datum.

KAUAI ISLAND, HAWAII NO. 22

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

KAUAI ISLAND, HAWAII NO. 23



Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 4. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

KAUAI ISLAND, HAWAII — SHEET NUMBER 24

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 4. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

KAUAI ISLAND, HAWAII NO. 24

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii, Agricultural Experiment Station.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

KAUAI ISLAND, HAWAII NO. 25

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 4. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

KAUAI ISLAND, HAWAII — SHEET NUMBER 26

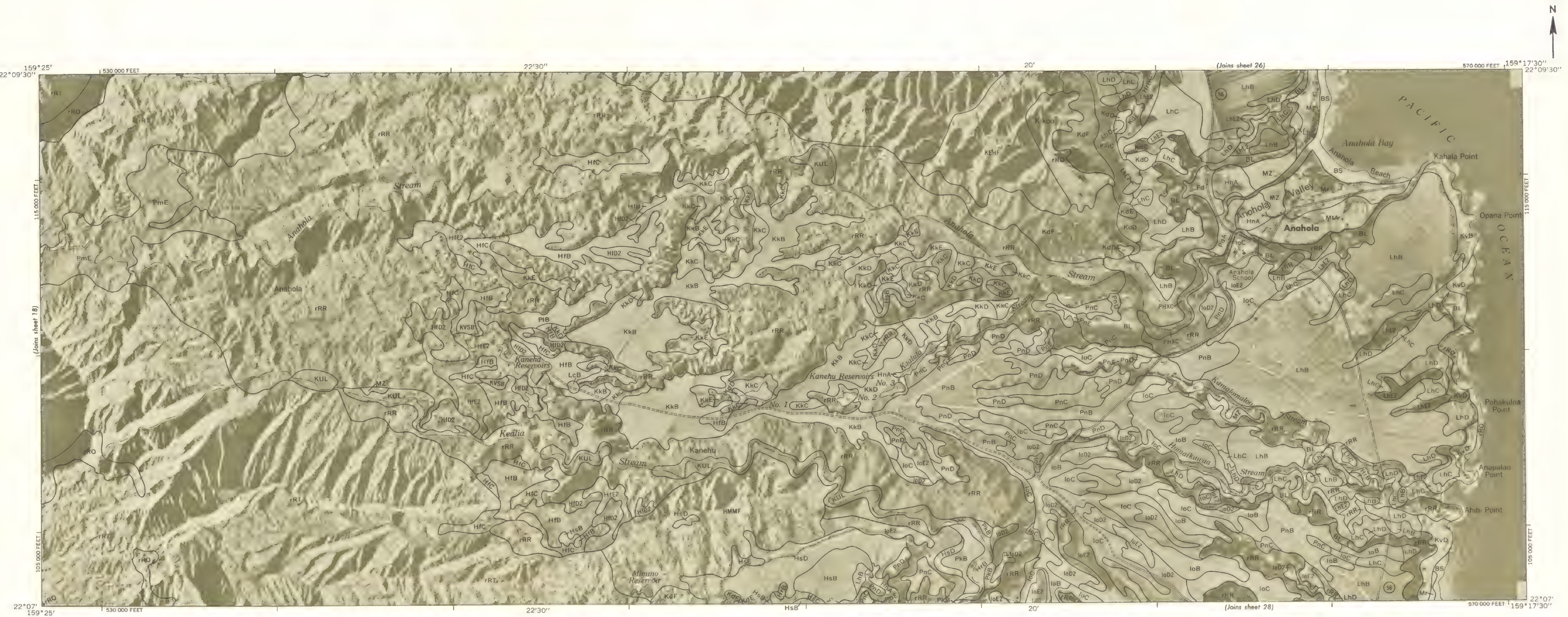
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 4 Old Hawaiian datum.

KAUAI ISLAND, HAWAII NO. 26

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

KAUAI ISLAND, HAWAII NO. 27



Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 4. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

KAUAI ISLAND, HAWAII — SHEET NUMBER 28

(28)

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 4. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

KAUAI ISLAND, HAWAII NO. 28

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

KAUAI ISLAND, HAWAII NO. 29

N

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 4. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 4. Old Hawaiian datum.

KAUAI ISLAND, HAWAII NO. 30

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

KAUAI ISLAND, HAWAII NO. 31

N

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 4. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

KAUAI ISLAND, HAWAII — SHEET NUMBER 32

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 4. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

KAUAI ISLAND, HAWAII NO. 32

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the University of Hawaii Agricultural Experiment Station.

OAHU ISLAND, HAWAII NO. 33

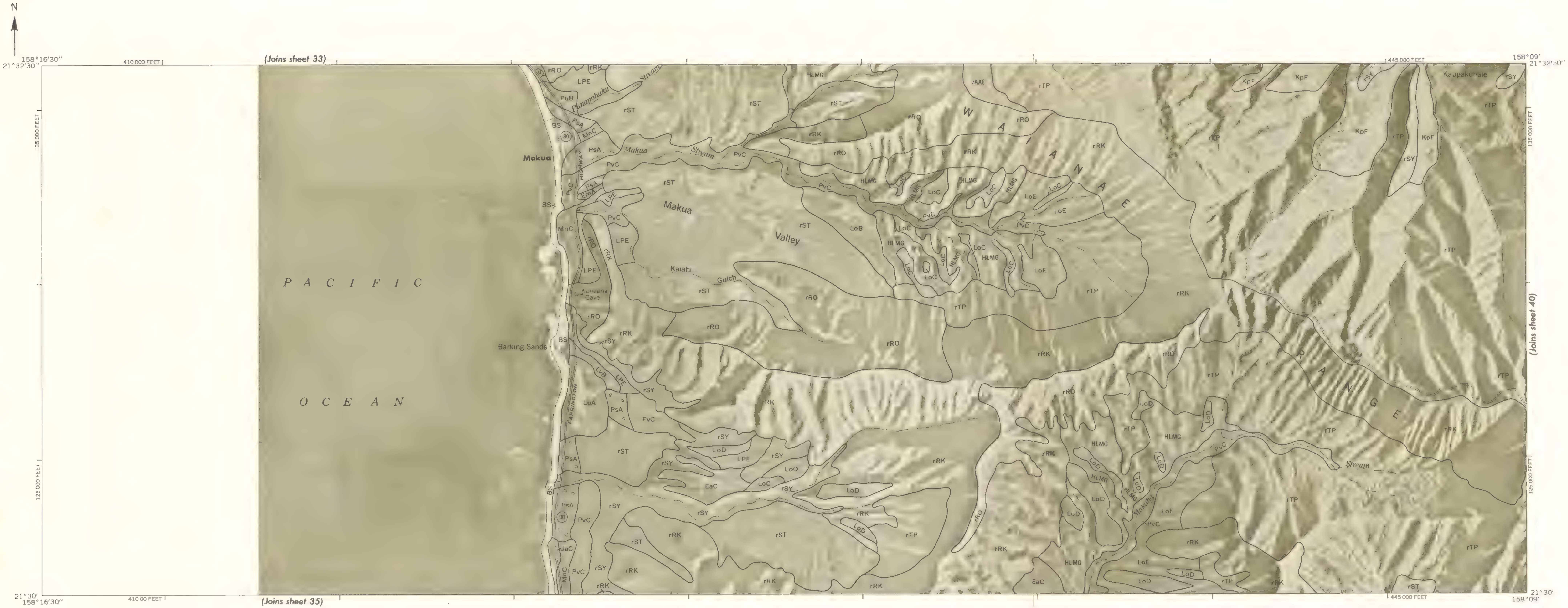
Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

Photobase from 1962, 1963 and 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 3. Old Hawaiian datum

OAHU ISLAND, HAWAII — SHEET NUMBER 34



Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

Photobase from 1962, 1963 and 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 3. Old Hawaiian datum.

OAHU ISLAND, HAWAII NO. 34

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the University of Hawaii Agricultural Experiment Station.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the University of Hawaii Agricultural Experiment Station.

OAHU ISLAND, HAWAII NO. 35

Photobase from 1962, 1963 and 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 3. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

Photobase from 1962, 1963 and 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 3. Old Hawaiian datum.

OAHU ISLAND, HAWAII NO. 36

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the University of Hawaii Agricultural Experiment Station

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This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the University of Hawaii Agricultural Experiment Station.

OAHU ISLAND, HAWAII NO. 37

Photobase from 1962, 1963 and 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 3. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

OAHU ISLAND, HAWAII — SHEET NUMBER 38

Scale 1:24 000

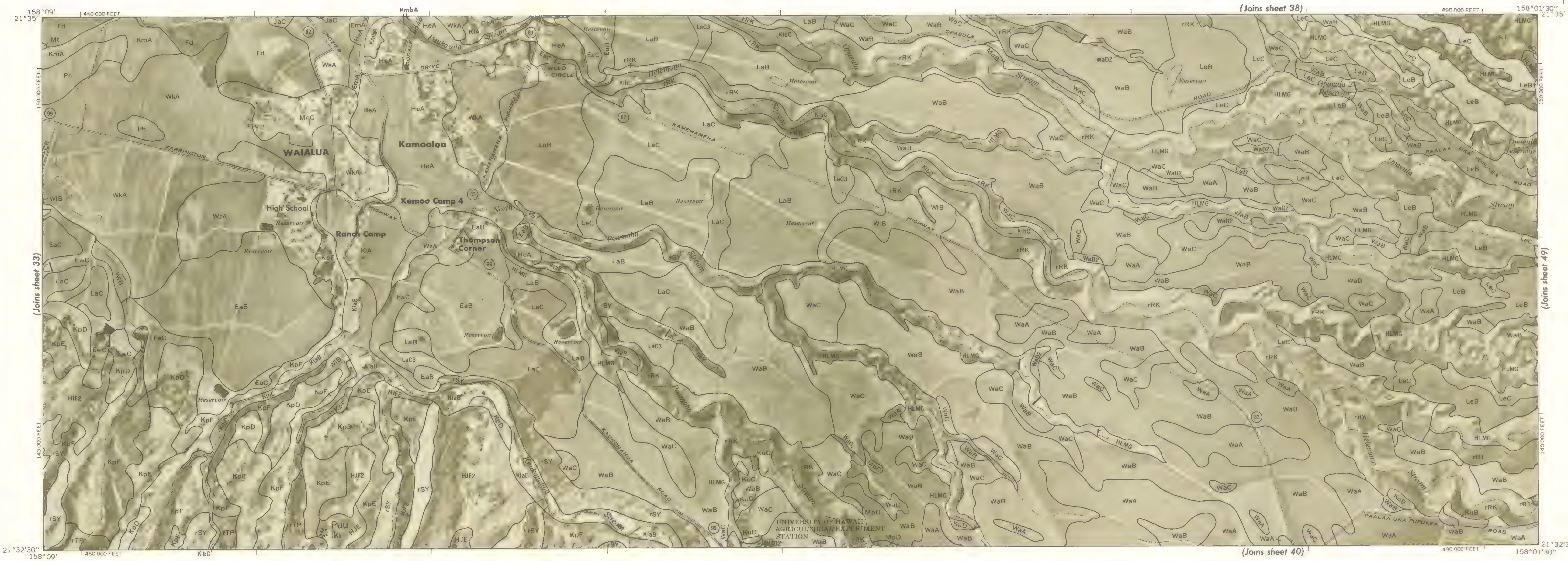
1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

Photobase from 1962, 1963 and 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 3. Old Hawaiian datum

OAHU ISLAND, HAWAII NO. 38

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the University of Hawaii Agricultural Experiment Station.



This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the University of Hawaii Agricultural Experiment Station

OAHU ISLAND, HAWAII NO. 39

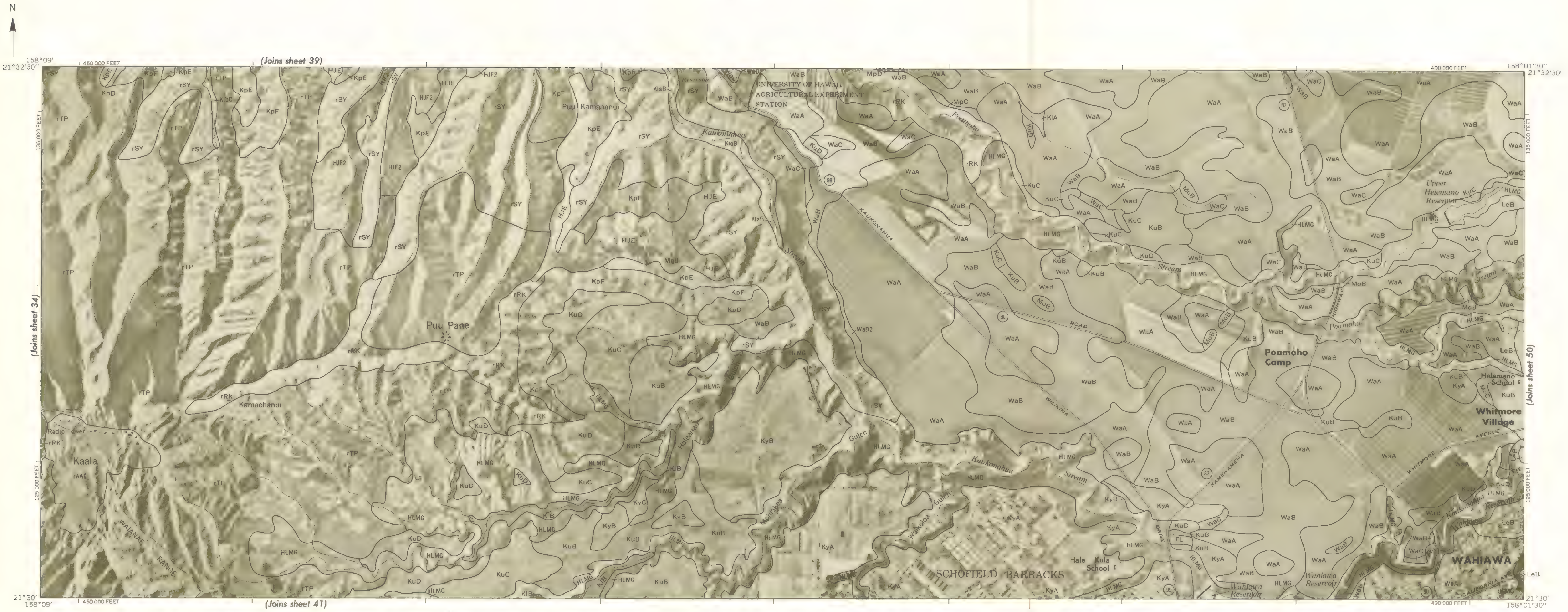
Photobase from 1962, 1963 and 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 3. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

OAHU ISLAND, HAWAII — SHEET NUMBER 40



Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

Photobase from 1962, 1963 and 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 3. Old Hawaiian datum.

OAHU ISLAND, HAWAII NO. 40

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the University of Hawaii Agricultural Experiment Station.

41

N

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the University of Hawaii Agricultural Experiment Station.

OAHU ISLAND, HAWAII NO. 41

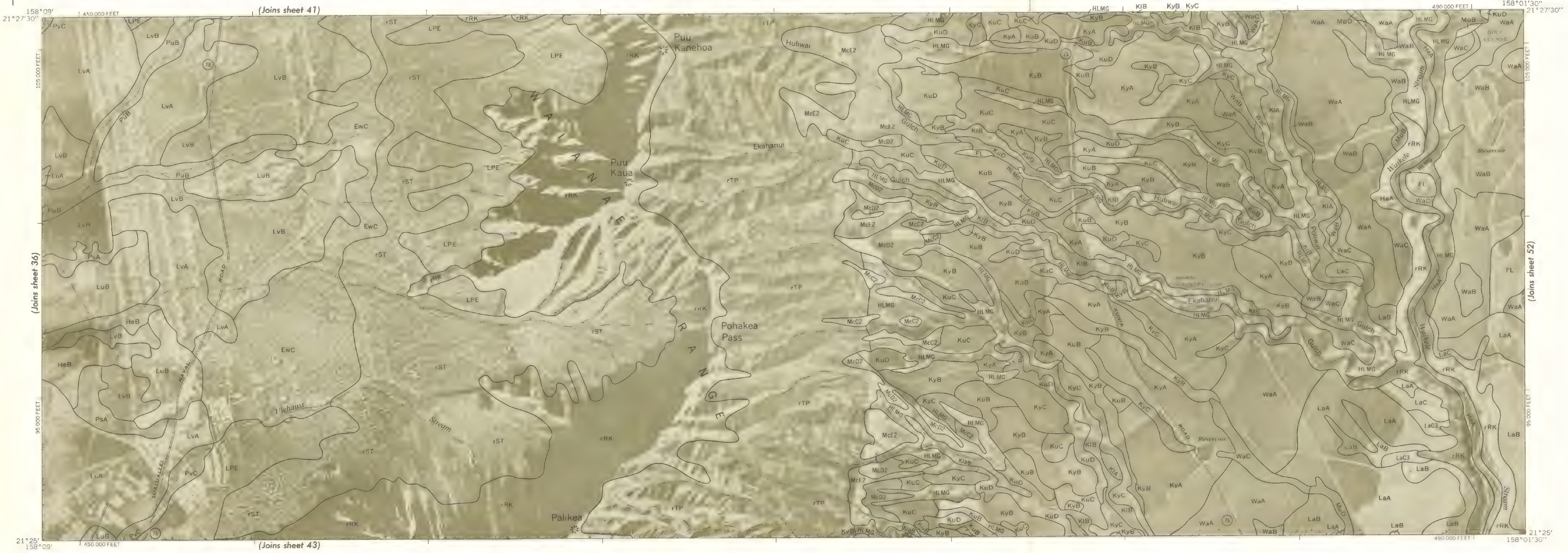
Photobase from 1962, 1963 and 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 3. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

N



Scale 1:24 000

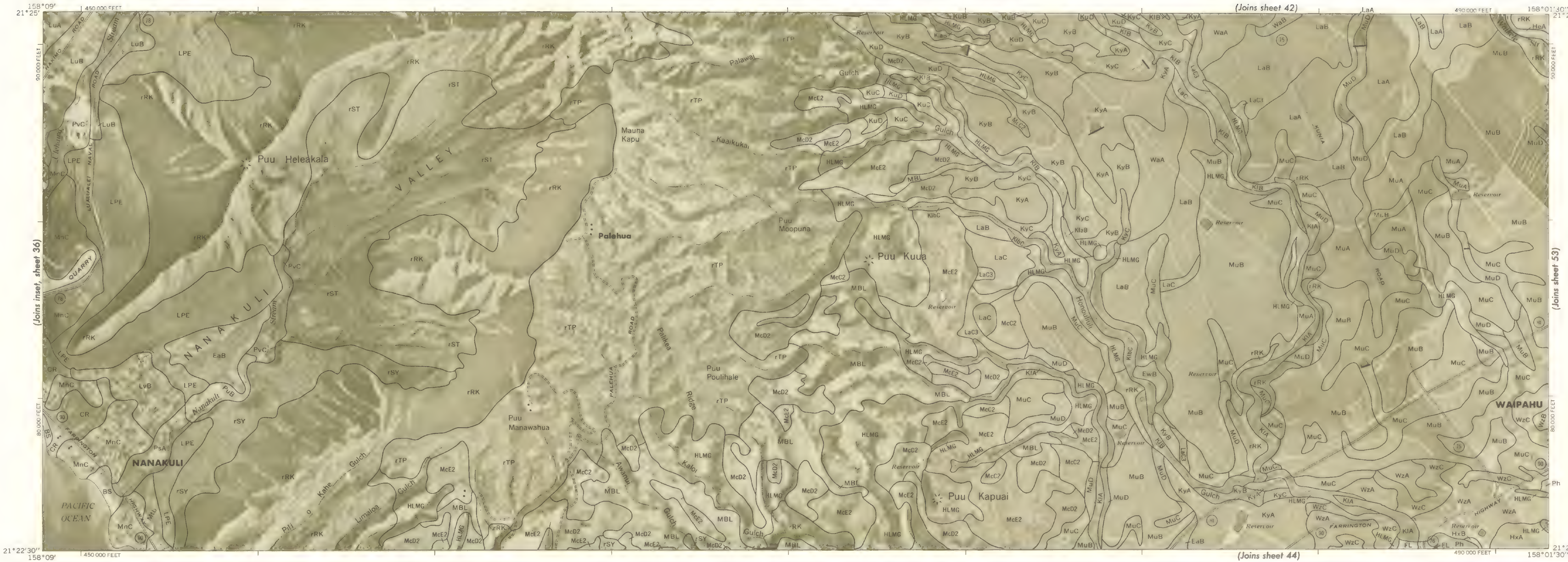
1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

Photobase from 1962, 1963 and 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 3. Old Hawaiian datum.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the University of Hawaii Agricultural Experiment Station.

N



OAHU ISLAND, HAWAII NO. 43

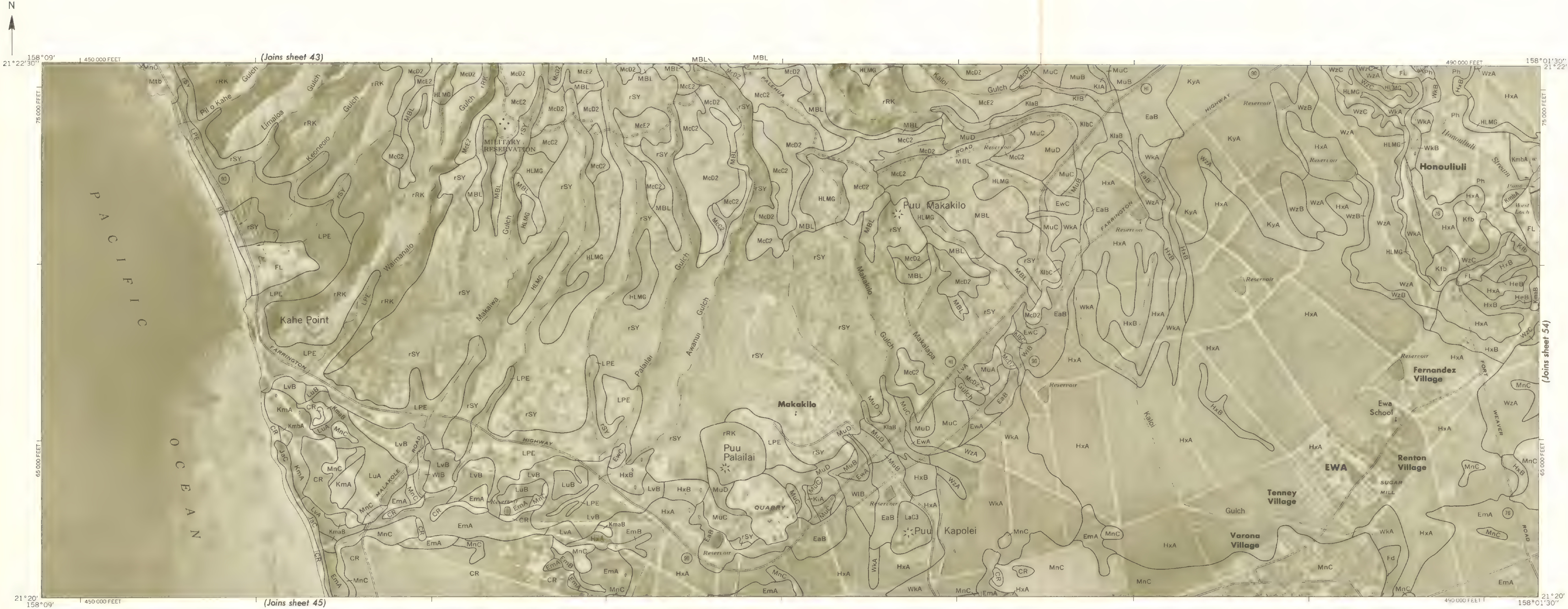
Photobase from 1962, 1963 and 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 3. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

OAHU ISLAND, HAWAII — SHEET NUMBER 44



Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

Photobase from 1962, 1963 and 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 3. Old Hawaiian datum.

OAHU ISLAND, HAWAII NO. 44

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the University of Hawaii Agricultural Experiment Station.

45

N

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the University of Hawaii Agricultural Experiment Station.

OAHU ISLAND, HAWAII NO. 45

Photobase from 1962, 1963 and 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 3. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

OAHU ISLAND, HAWAII — SHEET NUMBER 46

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

Photobase from 1962, 1963 and 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 3. Old Hawaiian datum.

OAHU ISLAND, HAWAII NO. 46

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the University of Hawaii Agricultural Experiment Station.

N

158°01'30" 21°40'

495 000 FEET

(Joins sheet 46)

530 000 FEET

157°54' 21°40'

180 000 FEET

(Joins sheet 37)

21°37'30" 158°01'30"

495 000 FEET

(Joins sheet 48)

530 000 FEET

21°37'30" 157°54'

170 000 FEET

Photobase from 1962, 1963 and 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 3. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the University of Hawaii Agricultural Experiment Station.

OAHU ISLAND, HAWAII — SHEET NUMBER 48

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

Photobase from 1962, 1963 and 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 3. Old Hawaiian datum.

OAHU ISLAND, HAWAII NO. 48

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the University of Hawaii Agricultural Experiment Station.

49

N

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the University of Hawaii Agricultural Experiment Station.

OAHU ISLAND, HAWAII NO. 49

Photobase from 1962, 1963 and 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 3. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

OAHU ISLAND, HAWAII — SHEET NUMBER 50

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

Photobase from 1962, 1963 and 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 3. Old Hawaiian datum.

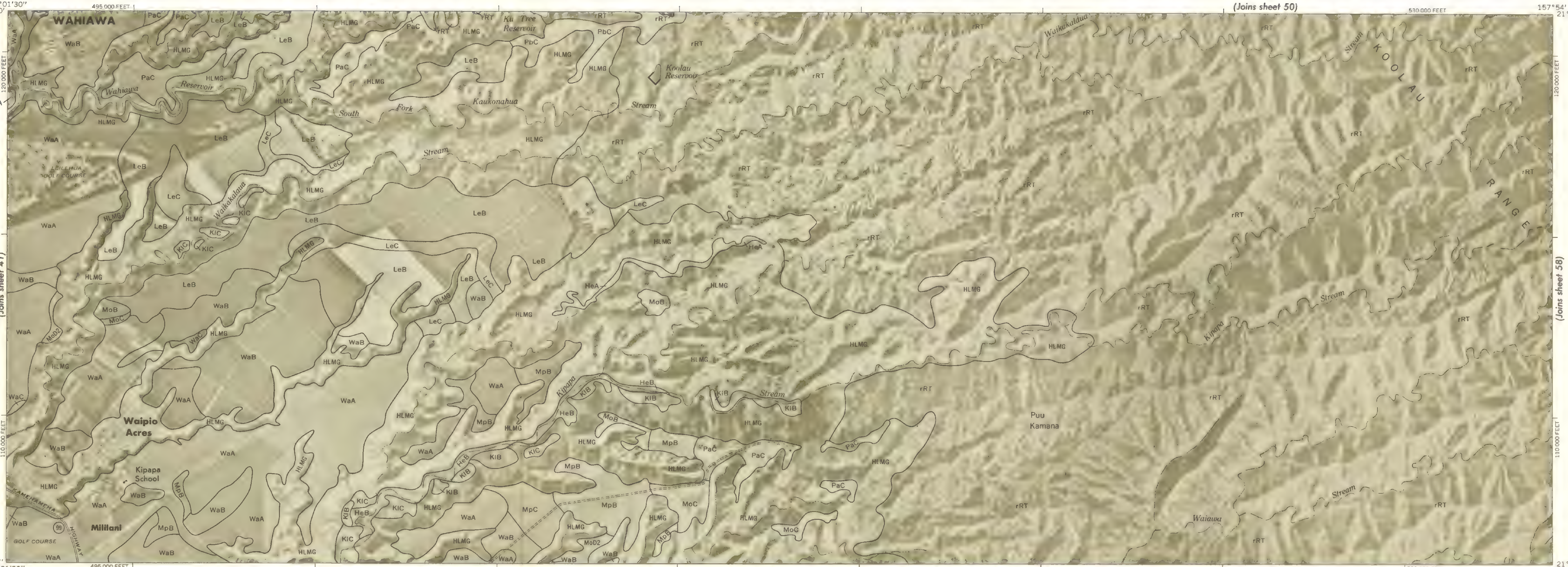
This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the University of Hawaii Agricultural Experiment Station.

OAHU ISLAND, HAWAII NO. 50

N

158°01'30"
21°30'
495 000 FEET
(Joins sheet 50)
530 000 FEET
157°54'
21°30'

(Joins sheet 41)



(Joins sheet 58)

21°27'30"
158°01'30"
495 000 FEET
(Joins sheet 52)
530 000 FEET
21°27'30"
157°54'

Photobase from 1962, 1963 and 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 3. Old Hawaiian datum.

Scale 1:24 000

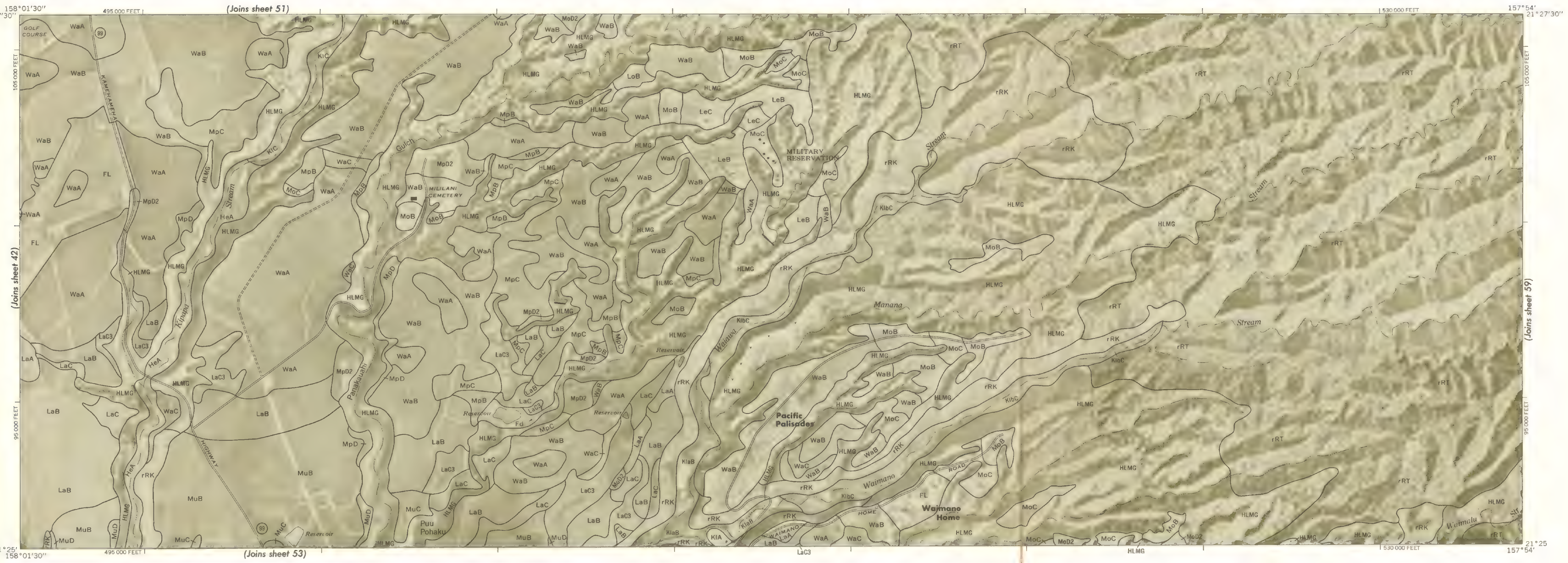
1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the University of Hawaii Agricultural Experiment Station.

OAHU ISLAND, HAWAII NO. 51

OAHU ISLAND, HAWAII — SHEET NUMBER 52



Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

Photobase from 1962, 1963 and 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 3. Old Hawaiian datum.

OAHU ISLAND, HAWAII NO. 52

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the University of Hawaii Agricultural Experiment Station.

N

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the University of Hawaii Agricultural Experiment Station.

OAHU ISLAND, HAWAII NO. 53

158°01'30" 21°25' — 495 000 FEET — (Joins sheet 52) — 530 000 FEET — 157°54' 21°25'

(Joins sheet 43) — (Joins sheet 60)

21°22'30" 158°01'30" — 495 000 FEET — MnC — (Joins sheet 54) — 530 000 FEET — 21°22'30" 157°54'

Photobase from 1962, 1963 and 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 3. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

OAHU ISLAND, HAWAII — SHEET NUMBER 54

Photobase from 1962, 1963 and 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 3. Old Hawaiian datum.

OAHU ISLAND, HAWAII NO. 54

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the University of Hawaii Agricultural Experiment Station.

N

Photobase from 1962, 1963 and 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 3. Old Hawaiian datum.

Scale 1:24 000

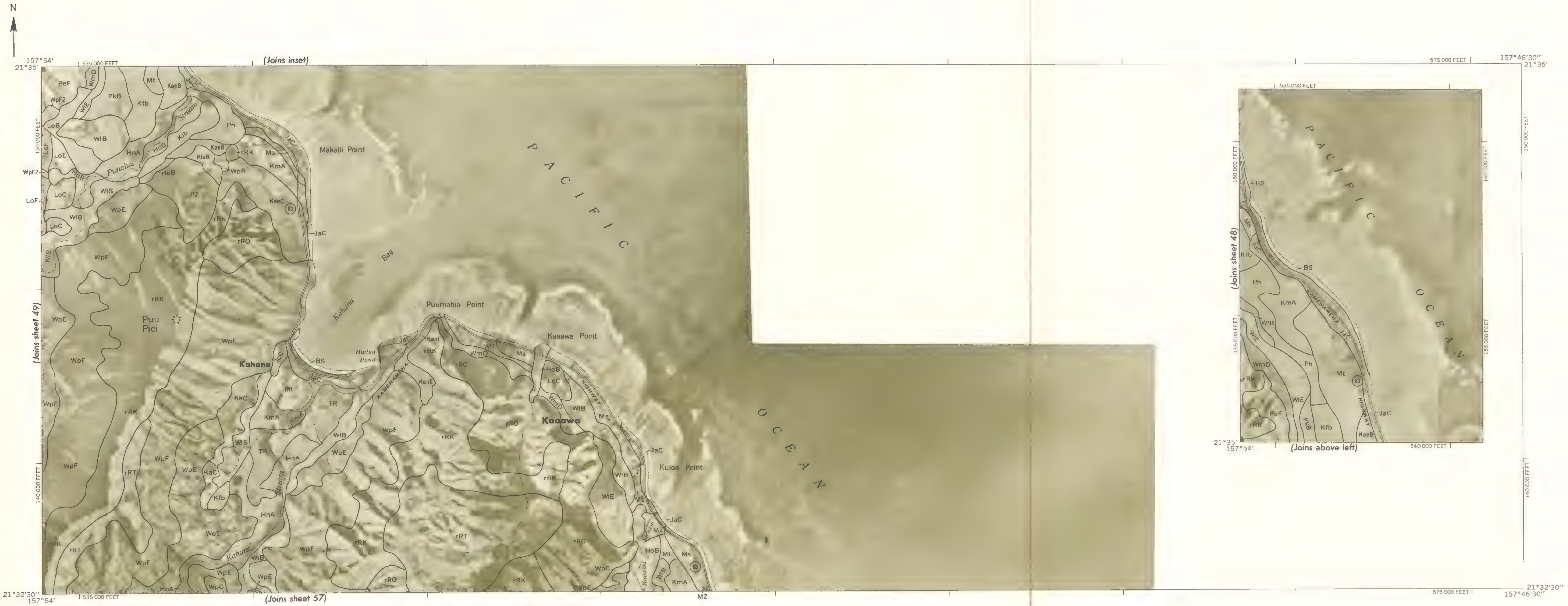
1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the University of Hawaii Agricultural Experiment Station.

OAHU ISLAND, HAWAII NO. 55

OAHU ISLAND, HAWAII — SHEET NUMBER 56



Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

Photobase from 1962, 1963 and 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 3. Old Hawaiian datum.

OAHU ISLAND, HAWAII NO. 56

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the University of Hawaii Agricultural Experiment Station.

N

Photobase from 1962, 1963 and 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 3. Old Hawaiian datum.

Scale 1:24 000

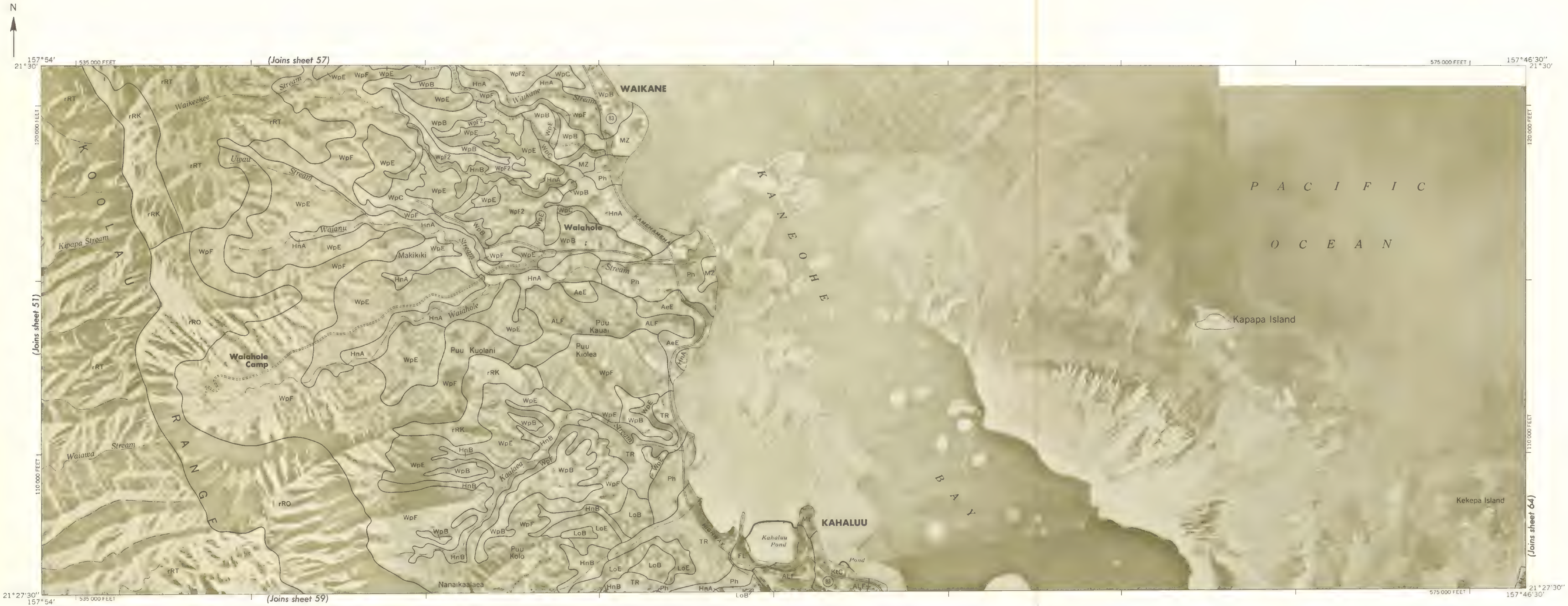
1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the University of Hawaii Agricultural Experiment Station.

OAHU ISLAND, HAWAII NO. 57

OAHU ISLAND, HAWAII — SHEET NUMBER 58



Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

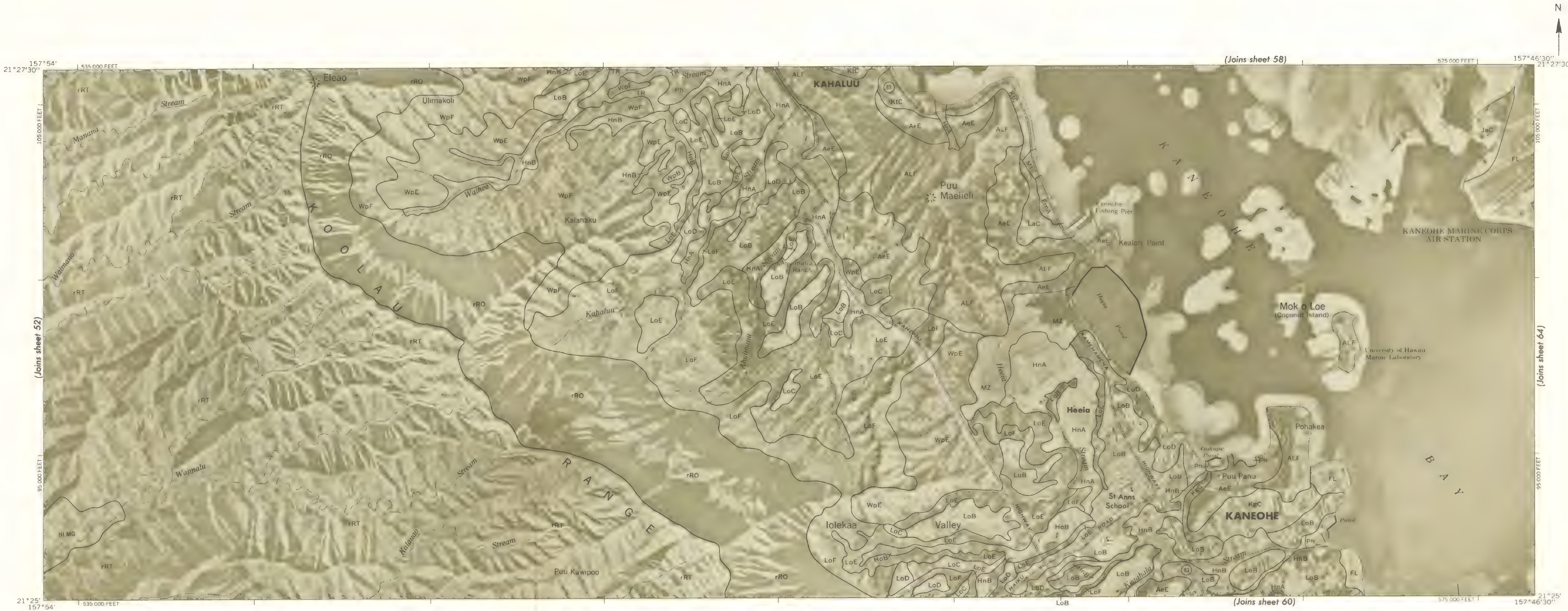
Photobase from 1962, 1963 and 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 3. Old Hawaiian datum.

OAHU ISLAND, HAWAII NO. 58

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the University of Hawaii Agricultural Experiment Station.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the University of Hawaii Agricultural Experiment Station.

OAHU ISLAND, HAWAII NO. 59



Photobase from 1962, 1963 and 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 3. Old Hawaiian datum

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

N

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

Photobase from 1962, 1963 and 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 3. Old Hawaiian datum.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the University of Hawaii Agricultural Experiment Station.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the University of Hawaii Agricultural Experiment Station

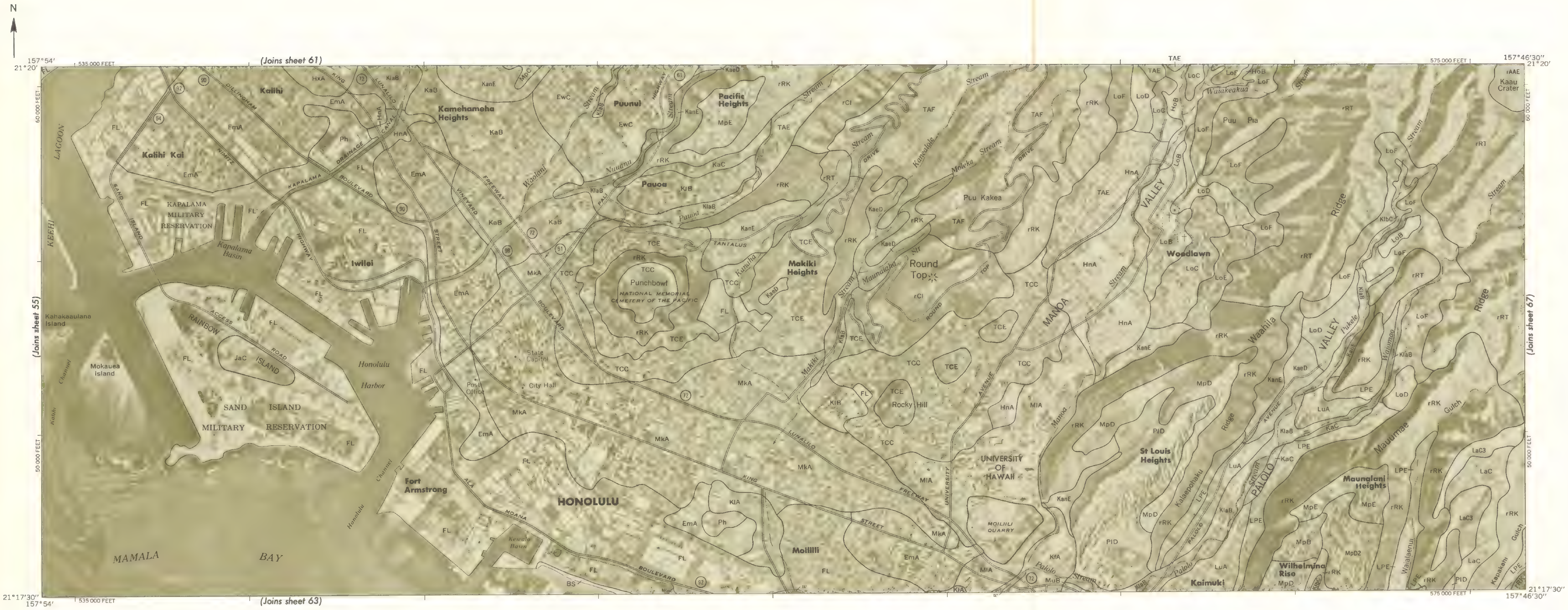
OAHU ISLAND, HAWAII NO. 61

Photobase from 1962, 1963 and 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 3. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet



Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

Photobase from 1962, 1963 and 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 3. Old Hawaiian datum.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the University of Hawaii Agricultural Experiment Station.

N

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the University of Hawaii Agricultural Experiment Station.

OAHU ISLAND, HAWAII NO. 63

Photobase from 1962, 1963 and 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 3. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

Photobase from 1962, 1963 and 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 3. Old Hawaiian datum.

OAHU ISLAND, HAWAII NO. 64

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the University of Hawaii Agricultural Experiment Station.

N

Photobase from 1962, 1963 and 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 3. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the University of Hawaii Agricultural Experiment Station.

OAHU ISLAND, HAWAII — SHEET NUMBER 66

N

157°46'30" 21°22'30" 580 000 FEET (Joins sheet 65) 615 000 FEET 157°39' 21°22'30"

21°20' 157°46'30" 580 000 FEET (Joins sheet 67) 615 000 FEET 157°39' 21°20'

Photobase from 1962, 1963 and 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 3. Old Hawaiian datum.

Scale 1:24 000

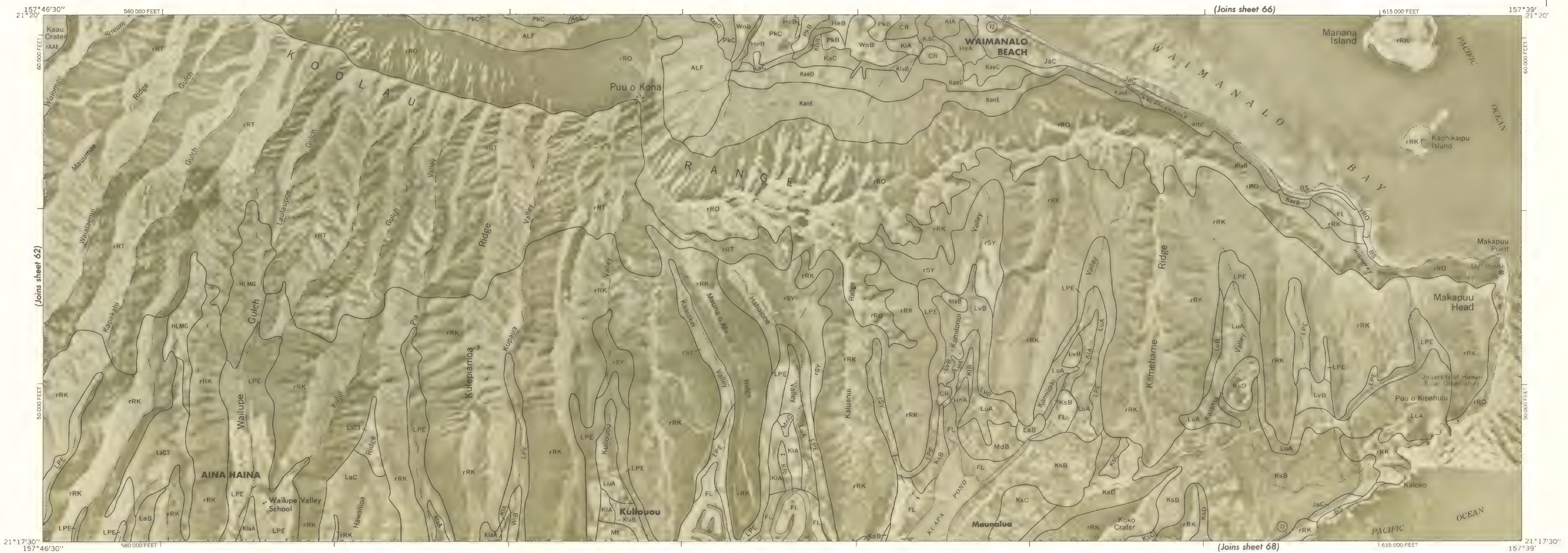
1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

OAHU ISLAND, HAWAII NO. 66

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the University of Hawaii Agricultural Experiment Station

N



Photobase from 1962, 1963 and 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 3. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the University of Hawaii Agricultural Experiment Station.

OAHU ISLAND, HAWAII NO. 67

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

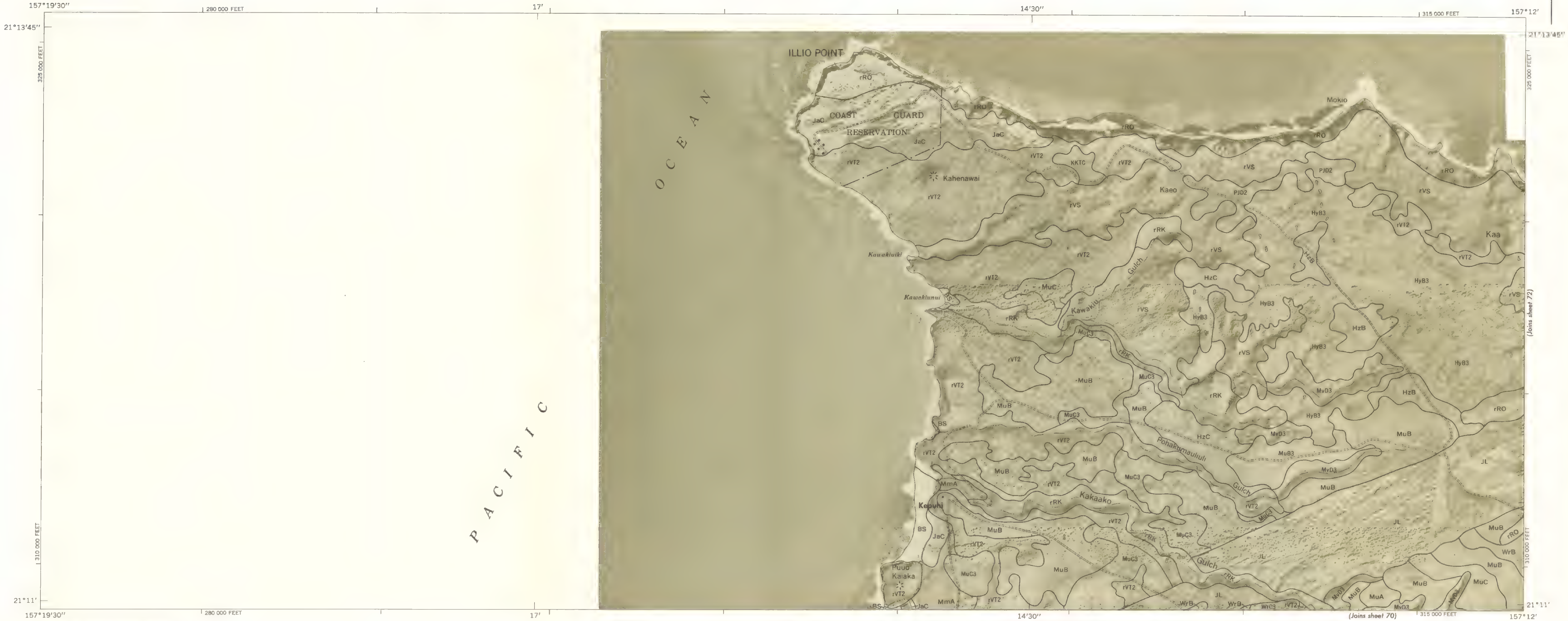
5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

Photobase from 1962, 1963 and 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 3. Old Hawaiian datum.

OAHU ISLAND, HAWAII NO. 68

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the University of Hawaii Agricultural Experiment Station.

MOLOKAI ISLAND, HAWAII NO. 69



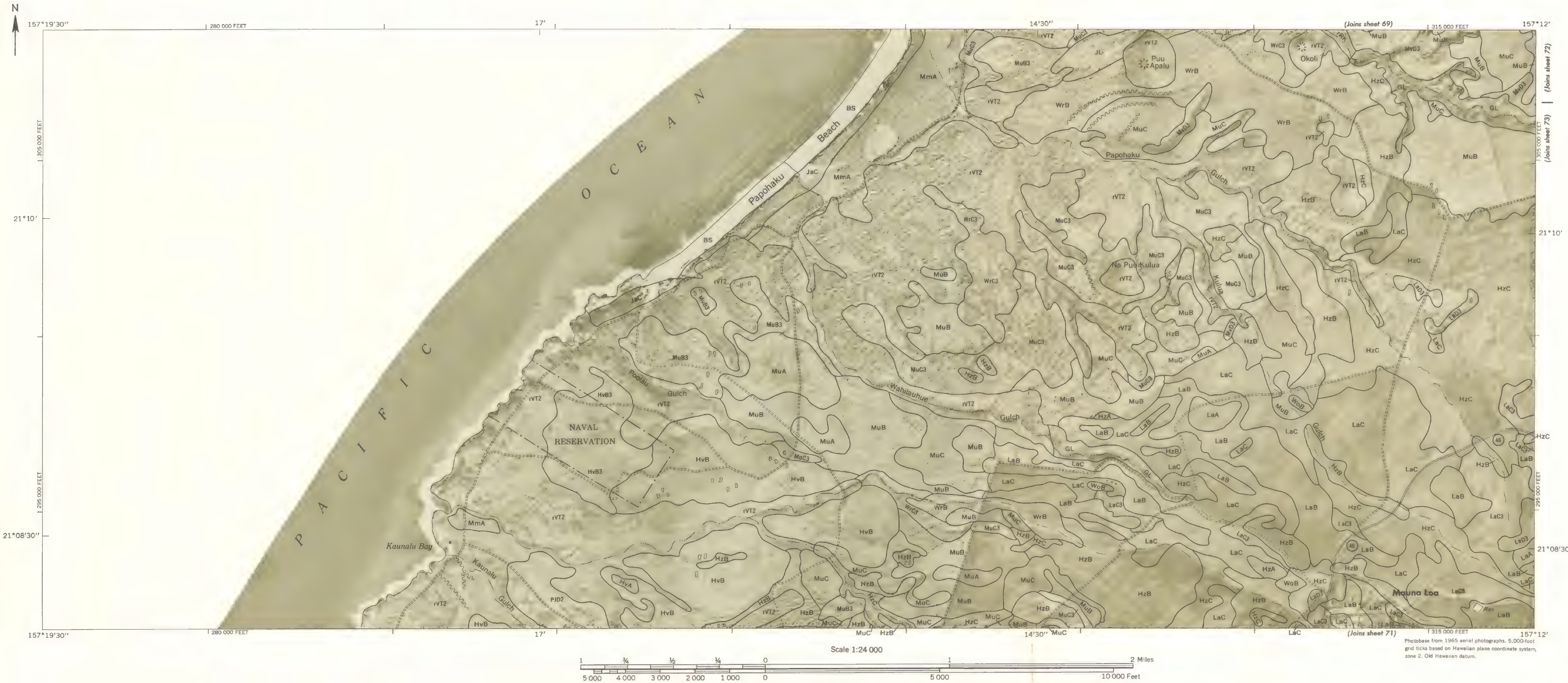
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

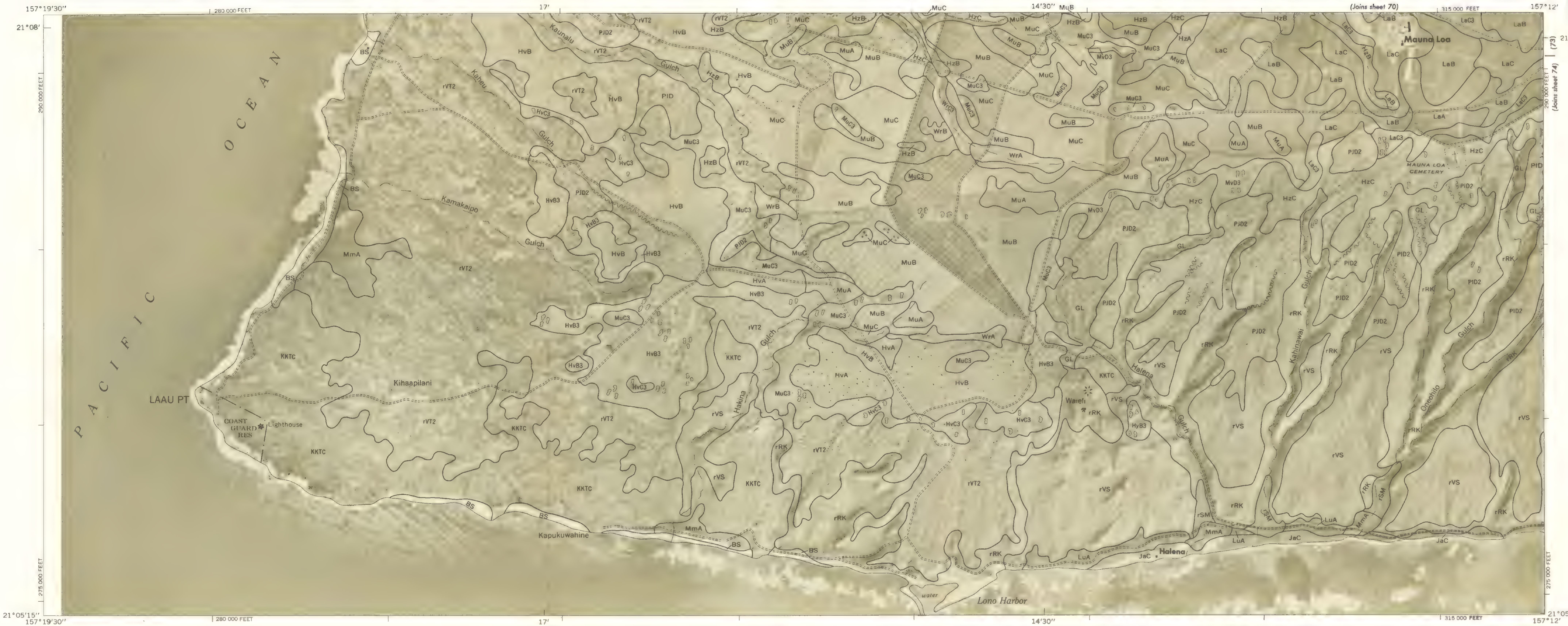
MOLOKAI ISLAND, HAWAII — SHEET NUMBER 70



MOLOKAI ISLAND, HAWAII NO. 70

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

71



Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

MOLOKAI ISLAND, HAWAII NO. 71

MOLOKAI ISLAND, HAWAII — SHEET NUMBER 72

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

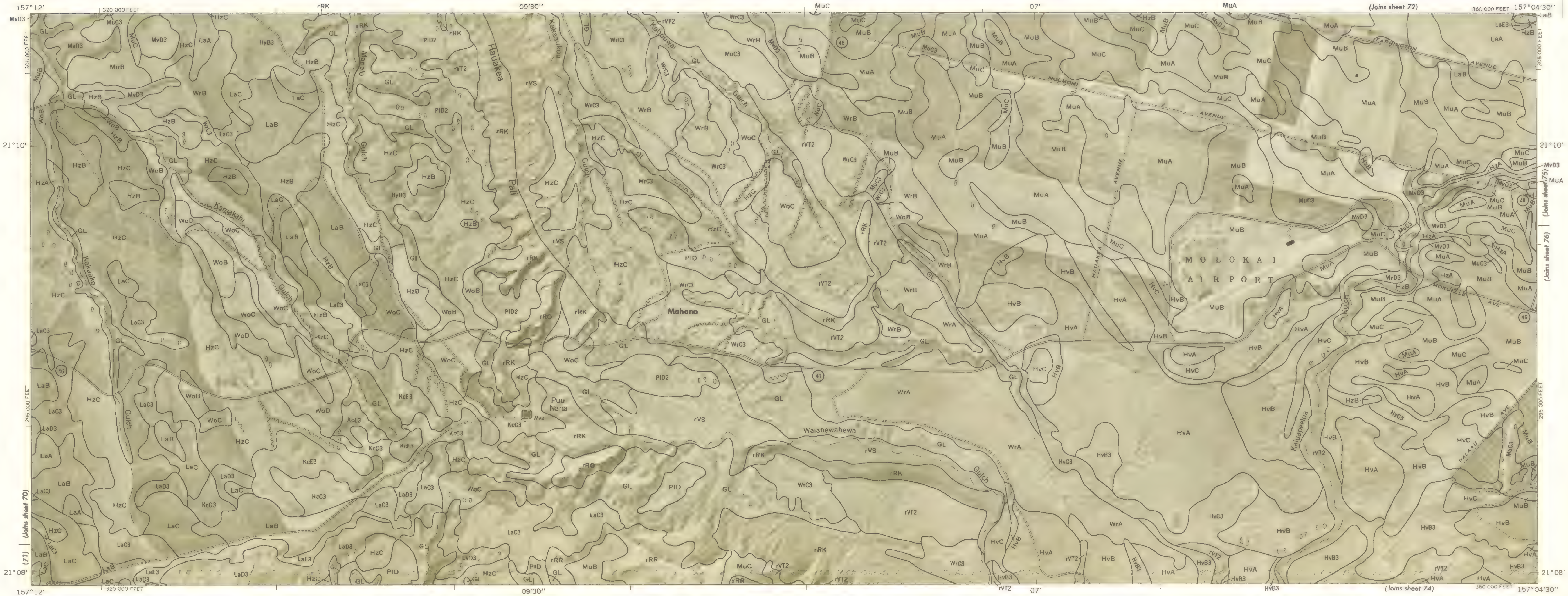
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2. Old Hawaiian datum.

MOLOKAI ISLAND, HAWAII NO. 72

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

73

N



MOLOKAI ISLAND, HAWAII NO. 73

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

MOLOKAI ISLAND, HAWAII — SHEET NUMBER 74

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

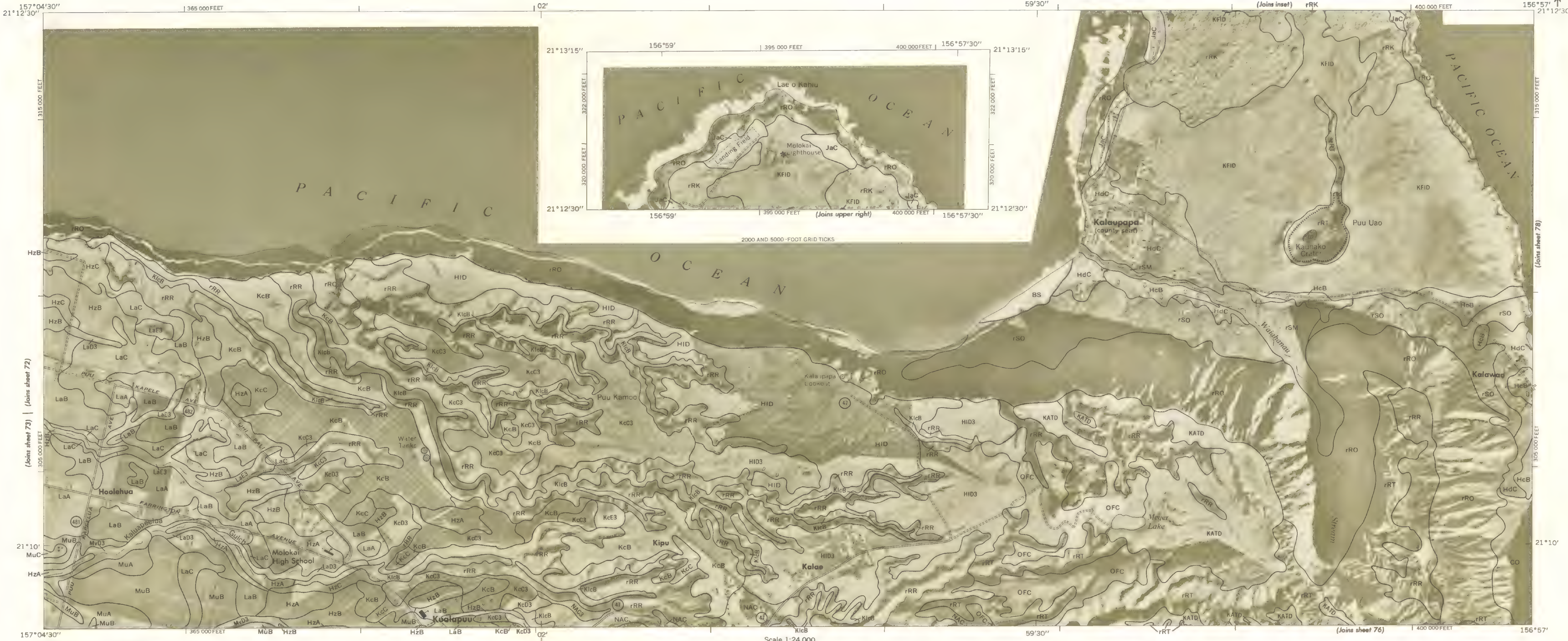
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2. Old Hawaiian datum.

MOLOKAI ISLAND, HAWAII NO. 74

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station

75

N



This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

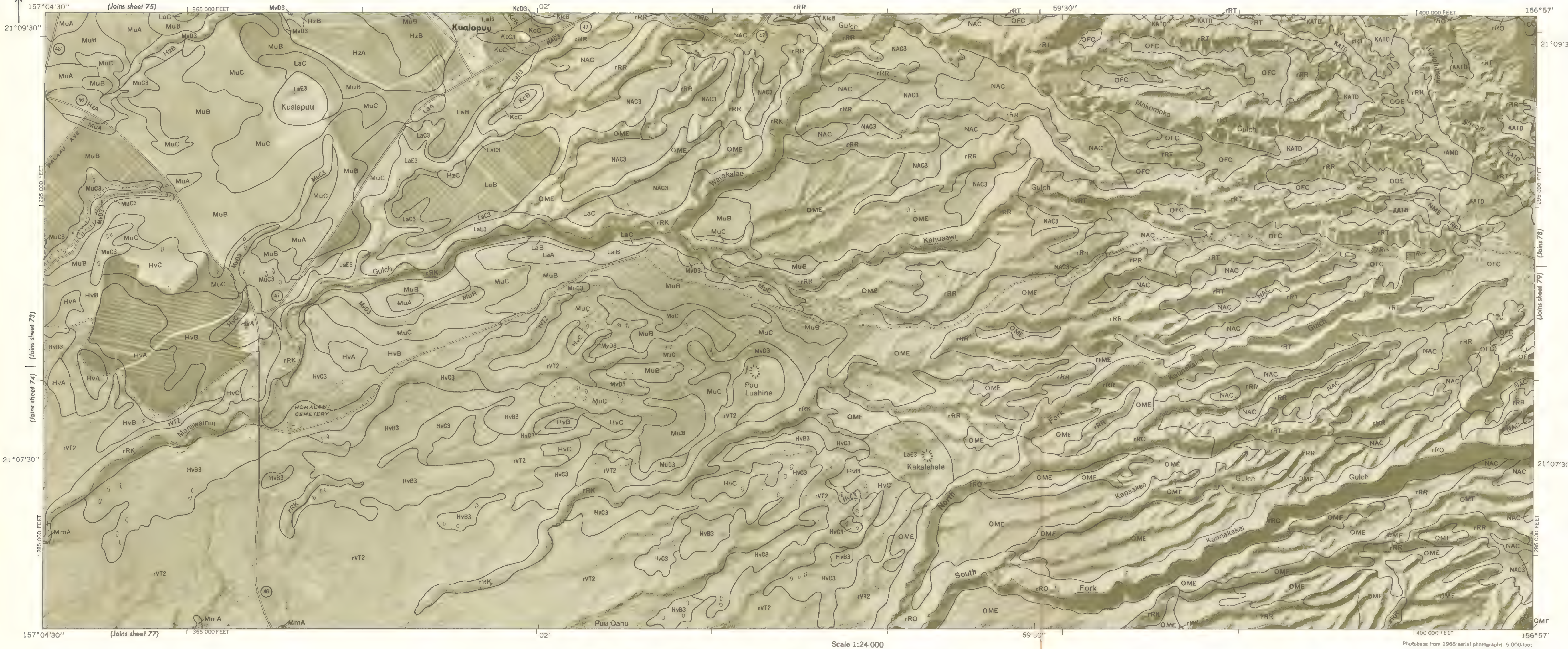
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2 Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

76
N



Scale 1:24 000

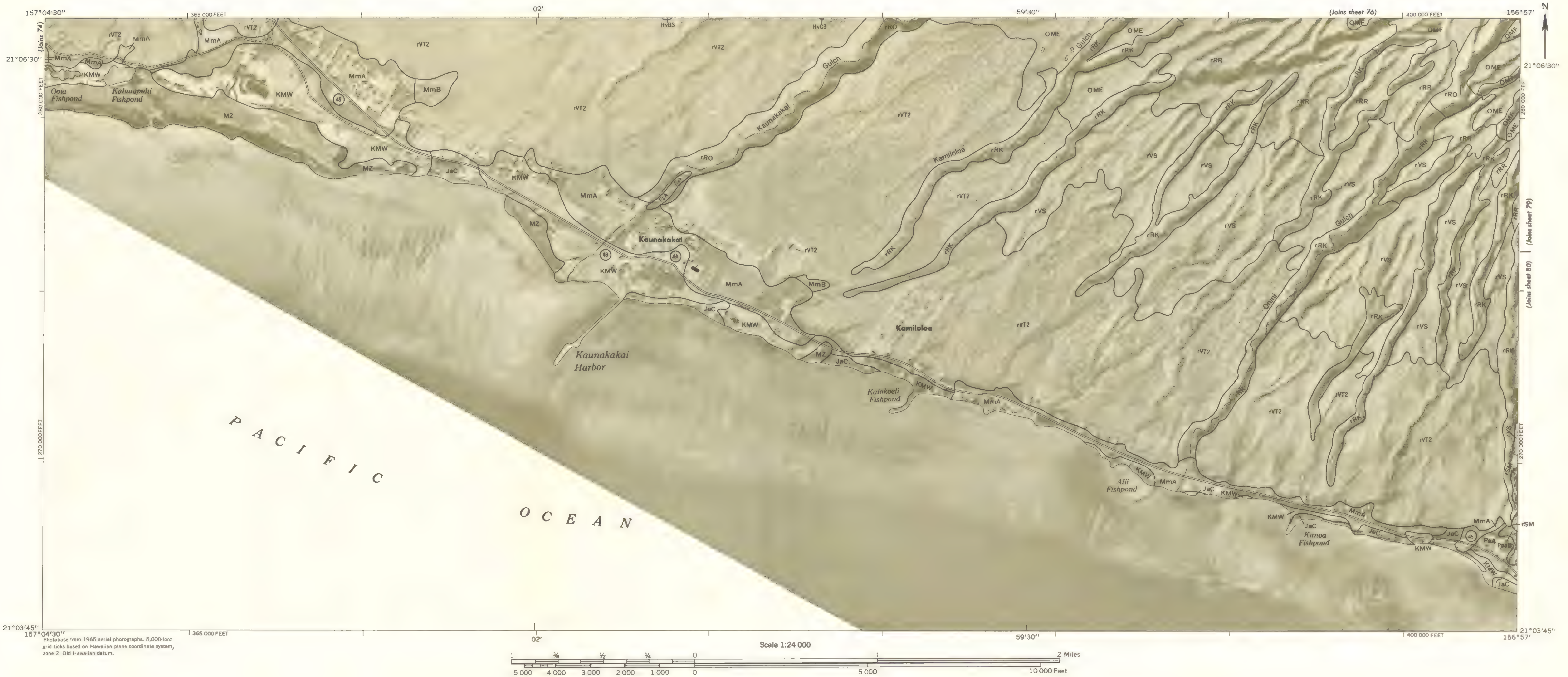
1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2. Old Hawaiian datum.

MOLOKAI ISLAND, HAWAII NO. 76

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.



This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

MOLOKAI ISLAND, HAWAII — SHEET NUMBER 78

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

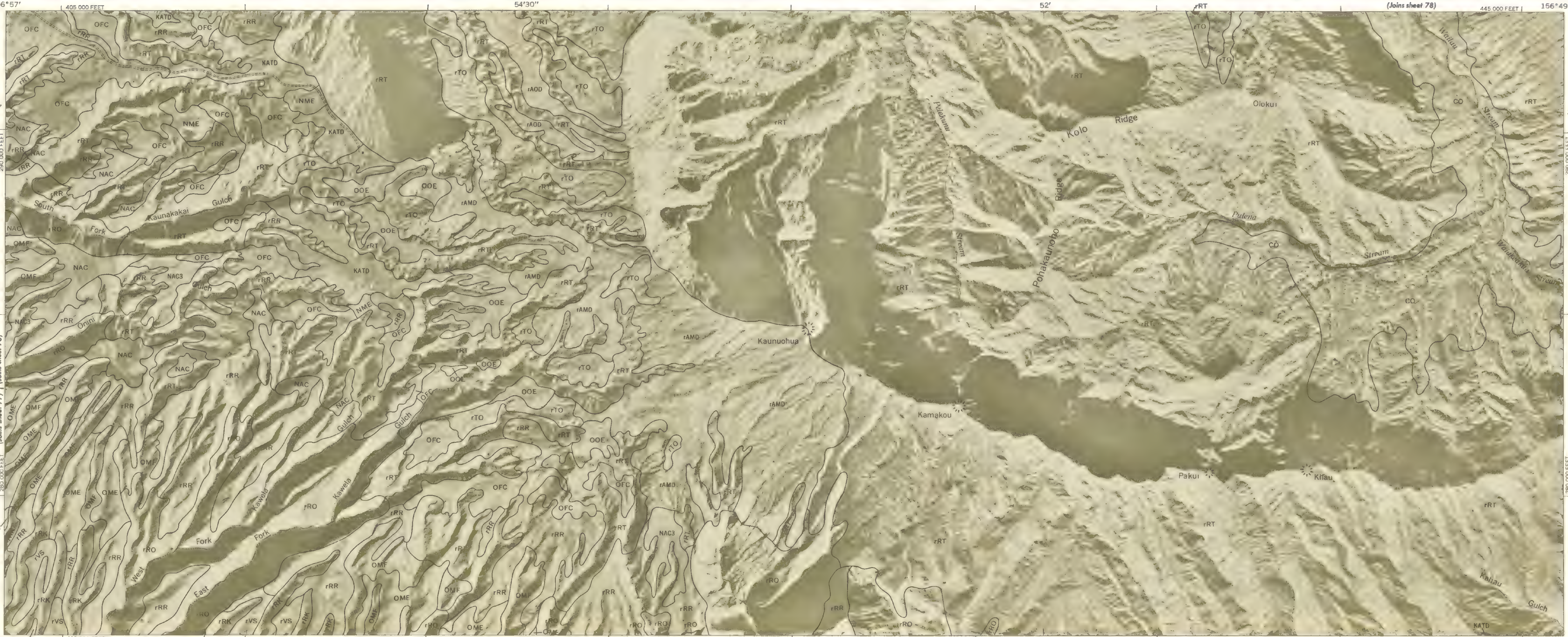
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2. Old Hawaiian datum.

MOLOKAI ISLAND, HAWAII NO. 78

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

MOLOKAI ISLAND, HAWAII NO. 79



Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2. Old Hawaiian datum.

MOLOKAI ISLAND, HAWAII NO. 80

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

81

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This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

MOLOKAI ISLAND, HAWAII NO. 81

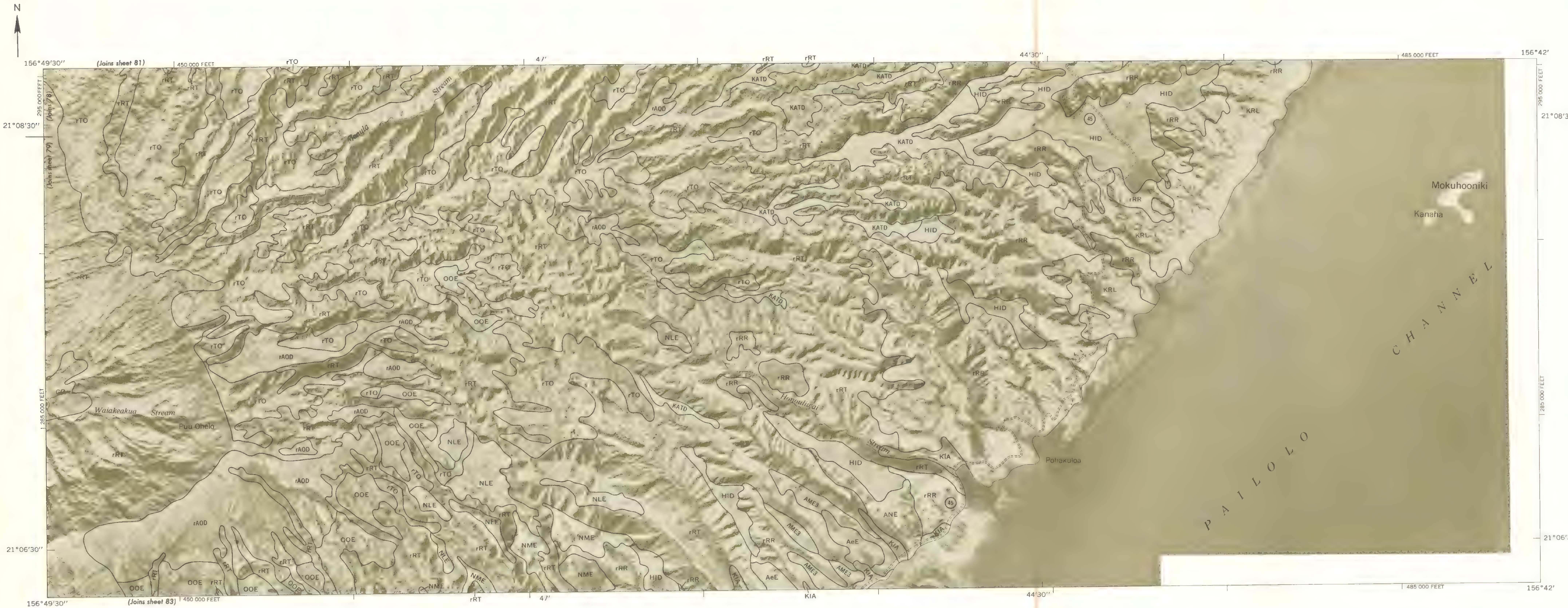
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

82



Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

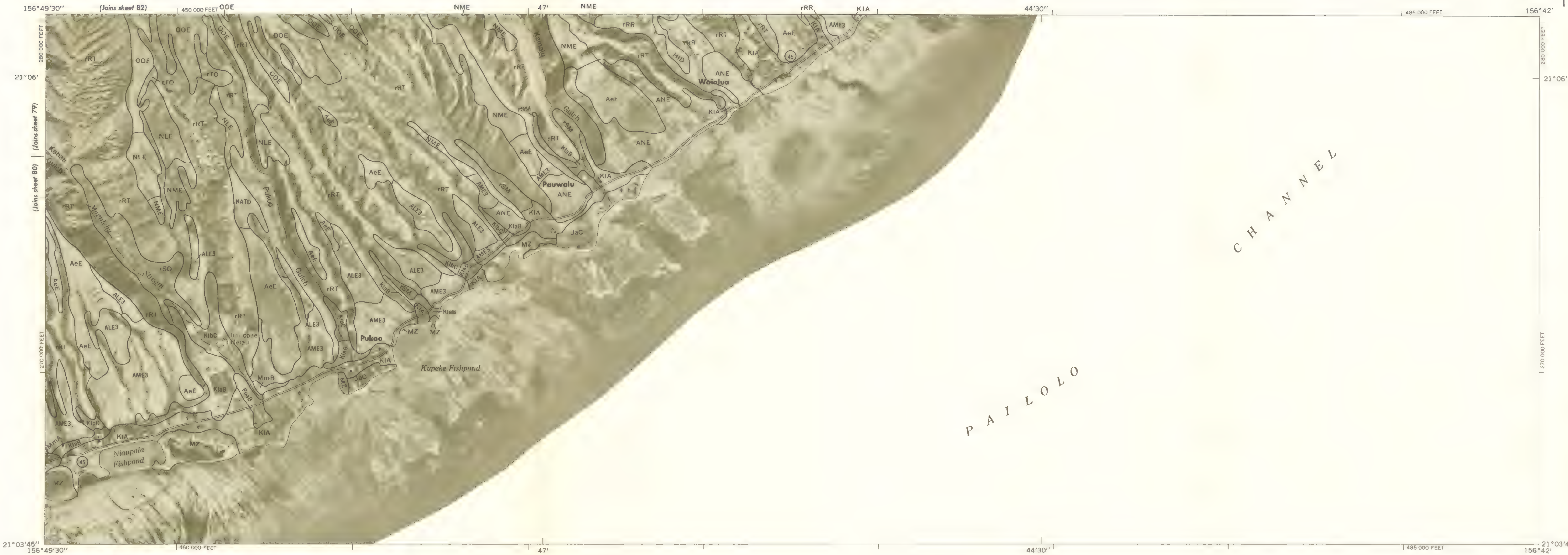
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2. Old Hawaiian datum.

MOLOKAI ISLAND, HAWAII NO. 82

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

MOLOKAI ISLAND, HAWAII NO. 83



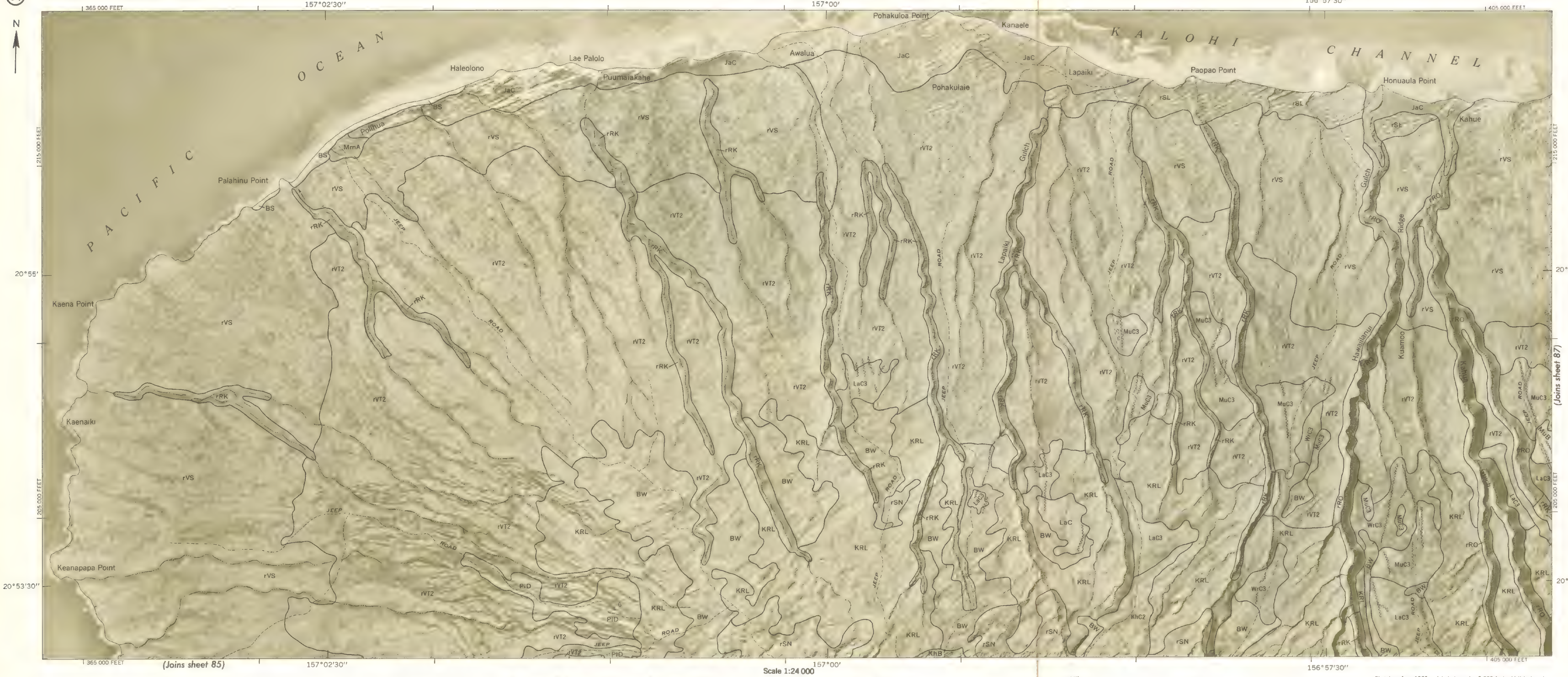
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

(84)



Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2. Old Hawaiian Datum.

LANAI ISLAND, HAWAII NO. 84

This map is one of a set compiled in 1970 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the University of Hawaii Agricultural Experiment Station.

This map is one of a set compiled in 1970 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the University of Hawaii Agricultural Experiment Station

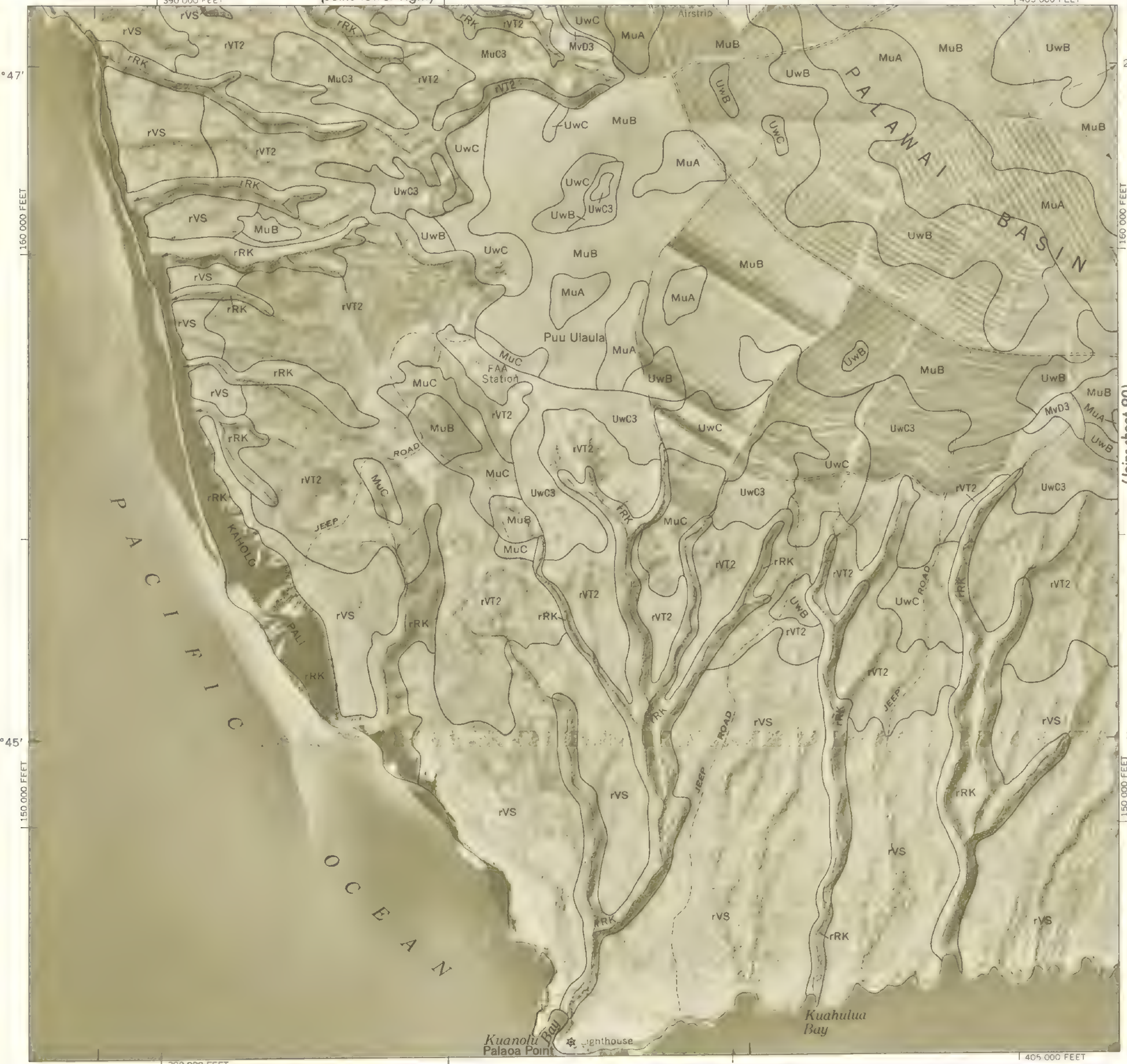
Photobase from 1965 aerial photographs, 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2. Old Hawaiian Datum.

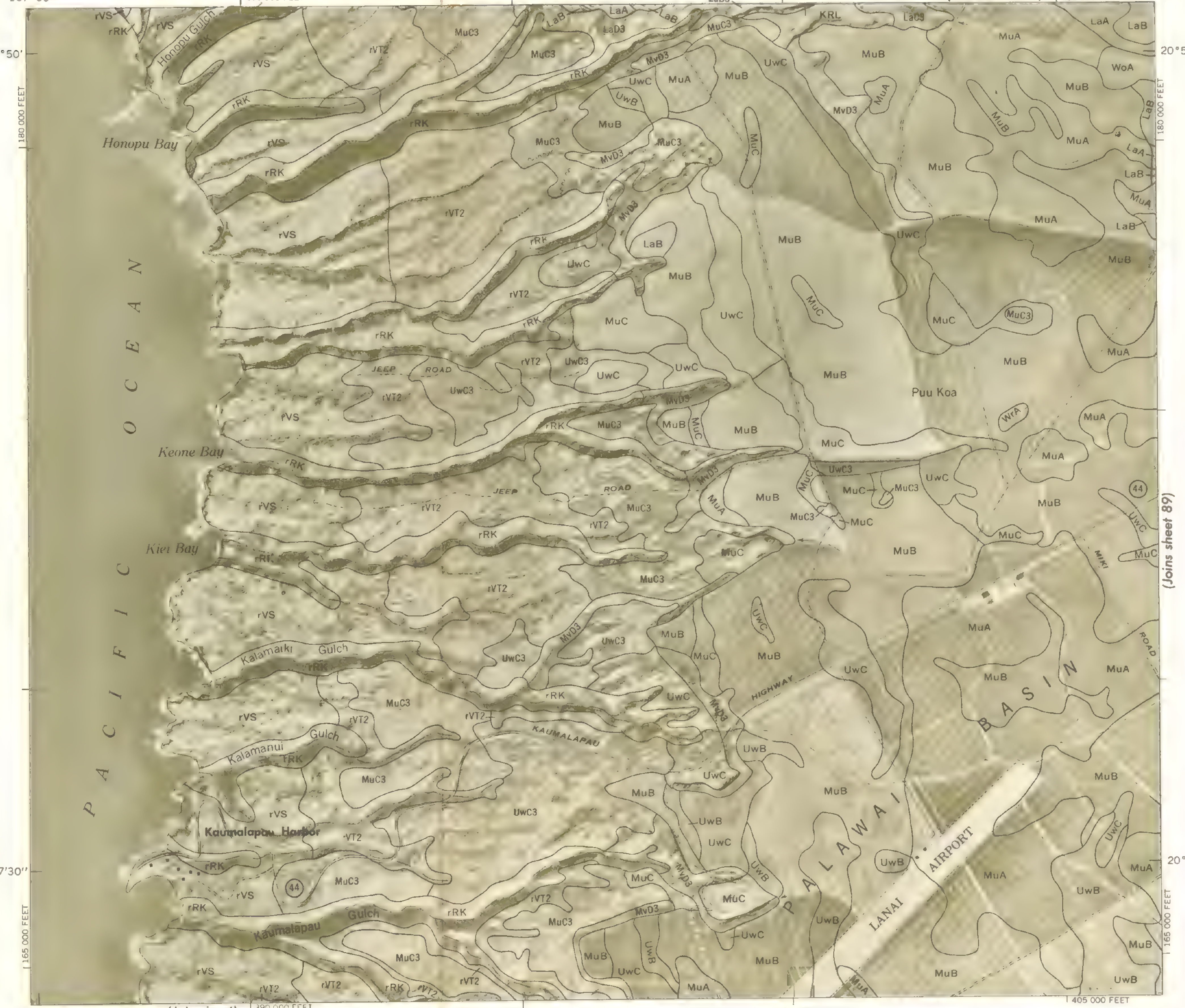
Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10 000 Feet

LANAI ISLAND, HAWAII — SHEET NUMBER 86





Scale 1:24 000

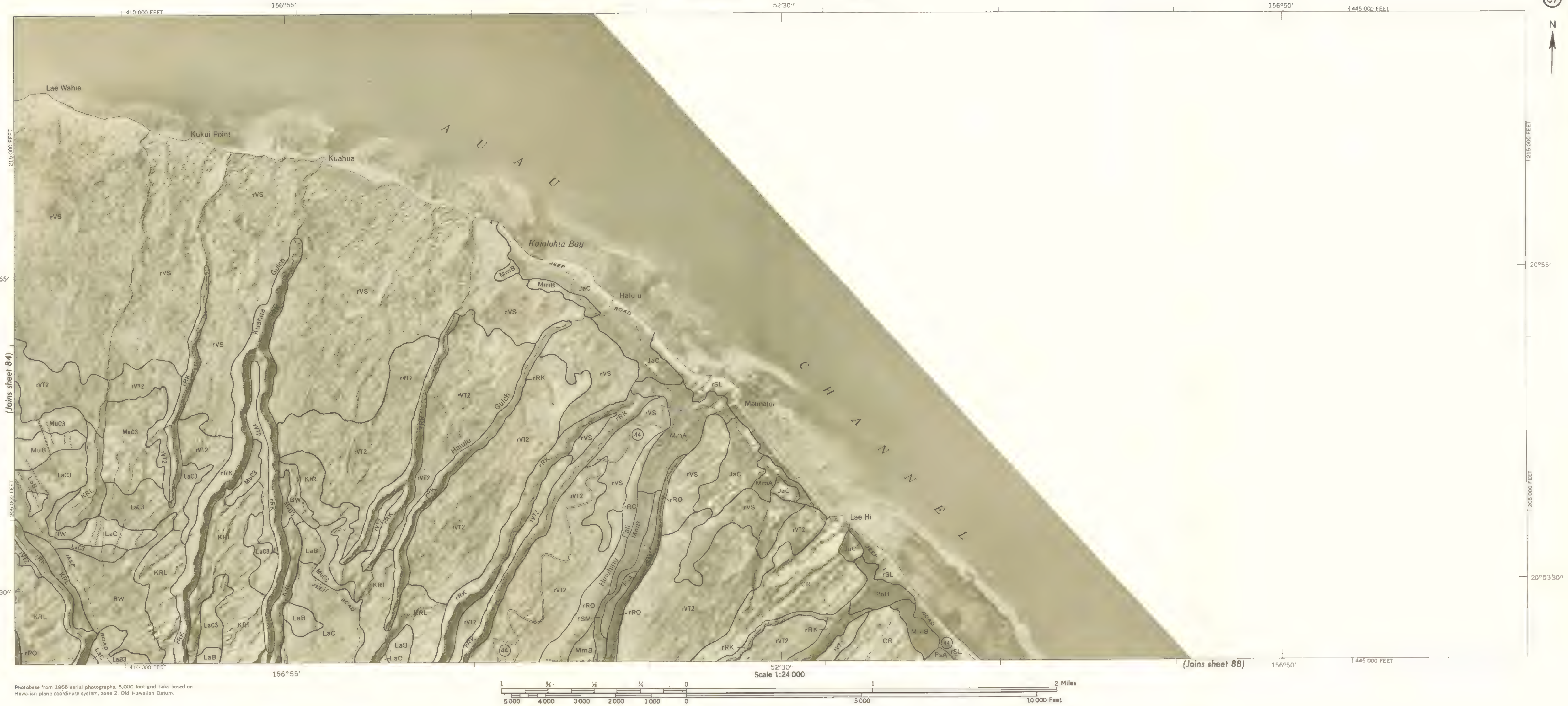
1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10 000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2. Old Hawaiian Datum.

LANAI ISLAND, HAWAII NO. 86

This map is one of a set compiled in 1970 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the University of Hawaii Agricultural Experiment Station



Photobase from 1965 aerial photographs. 5,000 foot grid ticks based on Hawaiian plane coordinate system, zone 2. Old Hawaiian Datum.

This map is one of a set compiled in 1970 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the University of Hawaii Agricultural Experiment Station

LANAI ISLAND, HAWAII — SHEET NUMBER 88

(Joins sheet 87)

(Joins sheet 89)

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10 000 Feet

Photobase from 1965 aerial photographs, 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2. Old Hawaiian Datum.

LANAI ISLAND, HAWAII NO. 88

This map is one of a set compiled in 1970 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the University of Hawaii Agricultural Experiment Station.

89

This map is one of a set compiled in 1970 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the University of Hawaii Agricultural Experiment Station

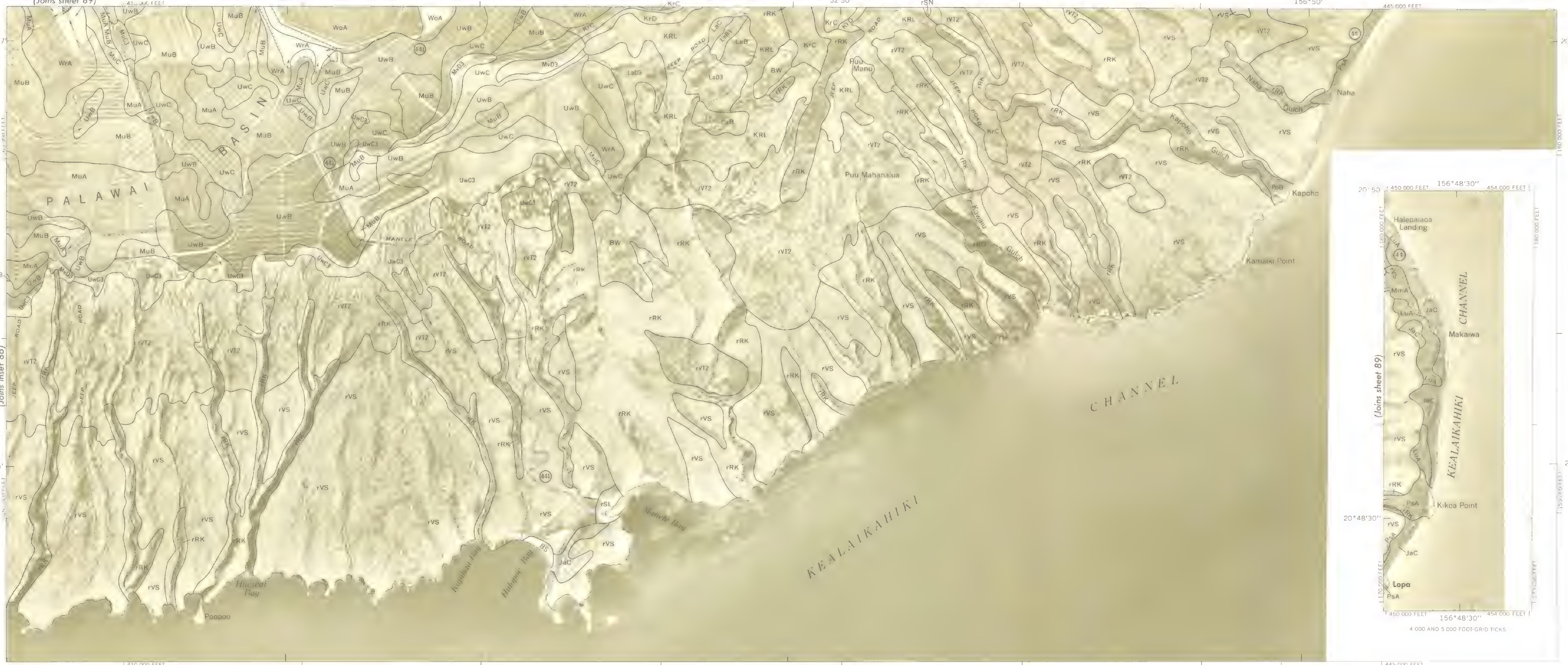
LANAI ISLAND, HAWAII NO. 89

Photobase from 1965 aerial photographs, 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2. Old Hawaiian Datum.

Scale 1:24 000

¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10 000 Feet

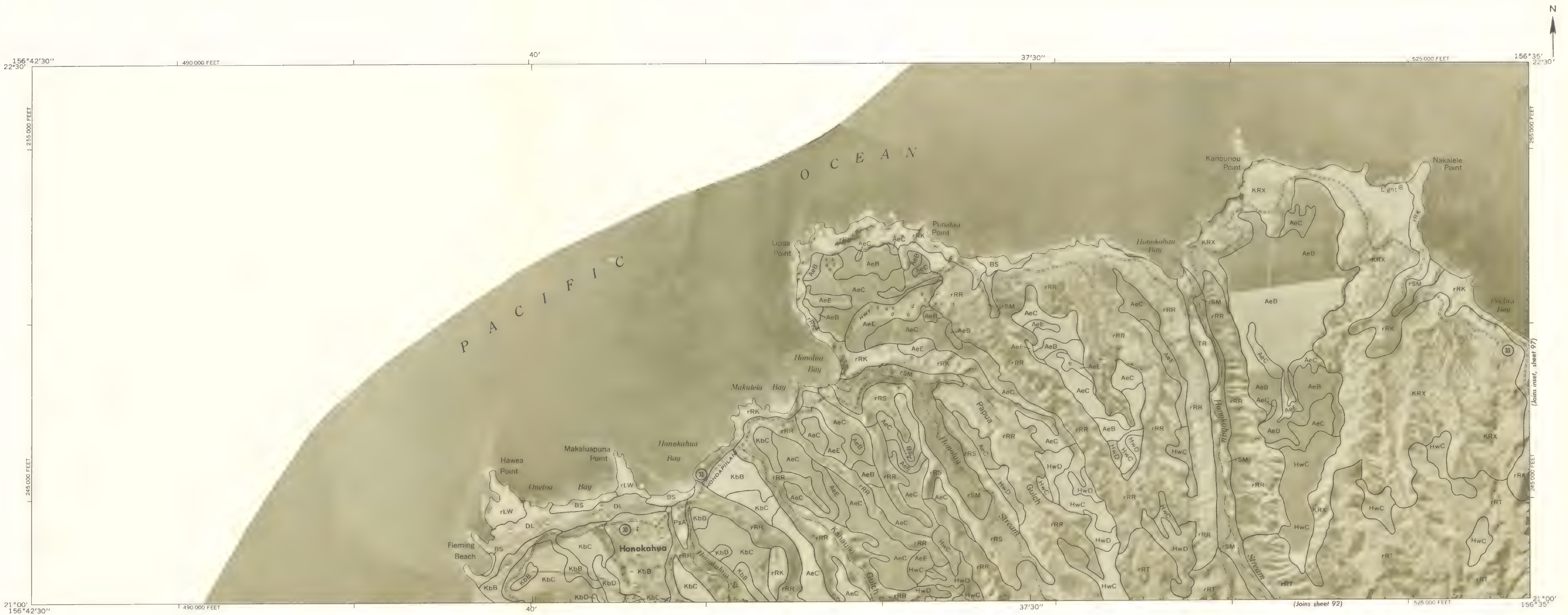


Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

Photobase from 1965 aerial photographs, 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2. Old Hawaiian Datum



Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

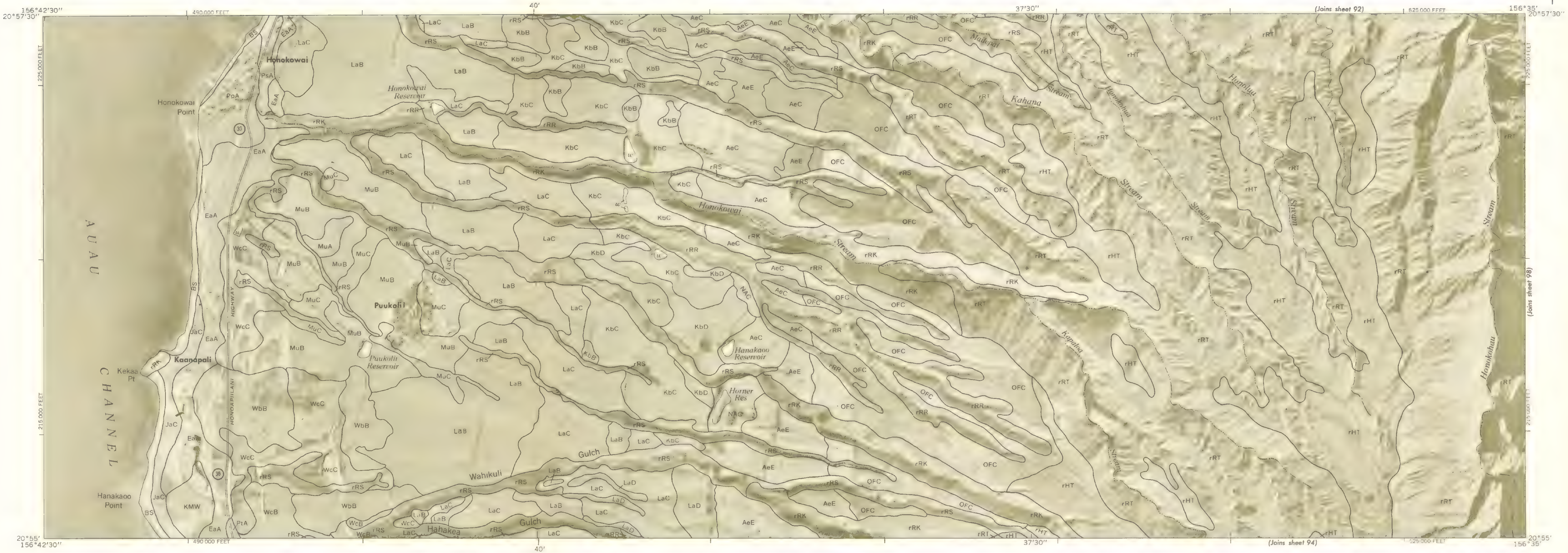
MAUI ISLAND, HAWAII NO. 91

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2 Old Hawaiian datum.

MAUI ISLAND, HAWAII NO. 92

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station



Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2. Old Hawaiian datum.

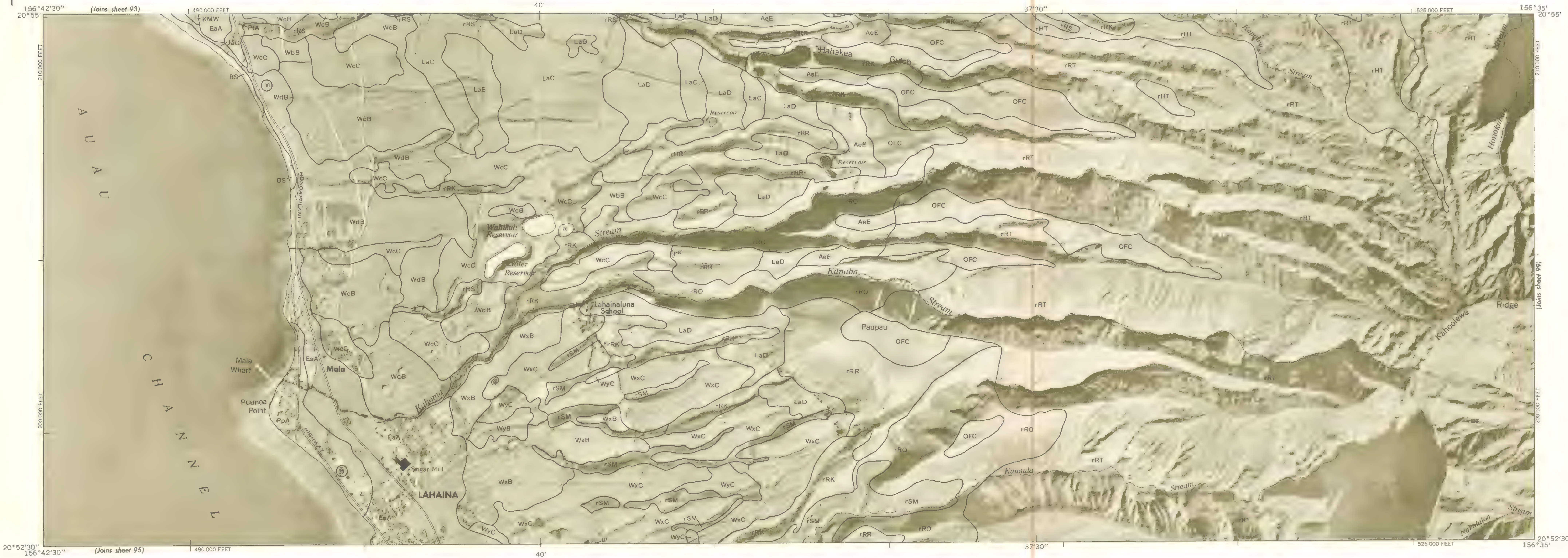
Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

MAUI ISLAND, HAWAII — SHEET NUMBER 94



Scale 1:24 000

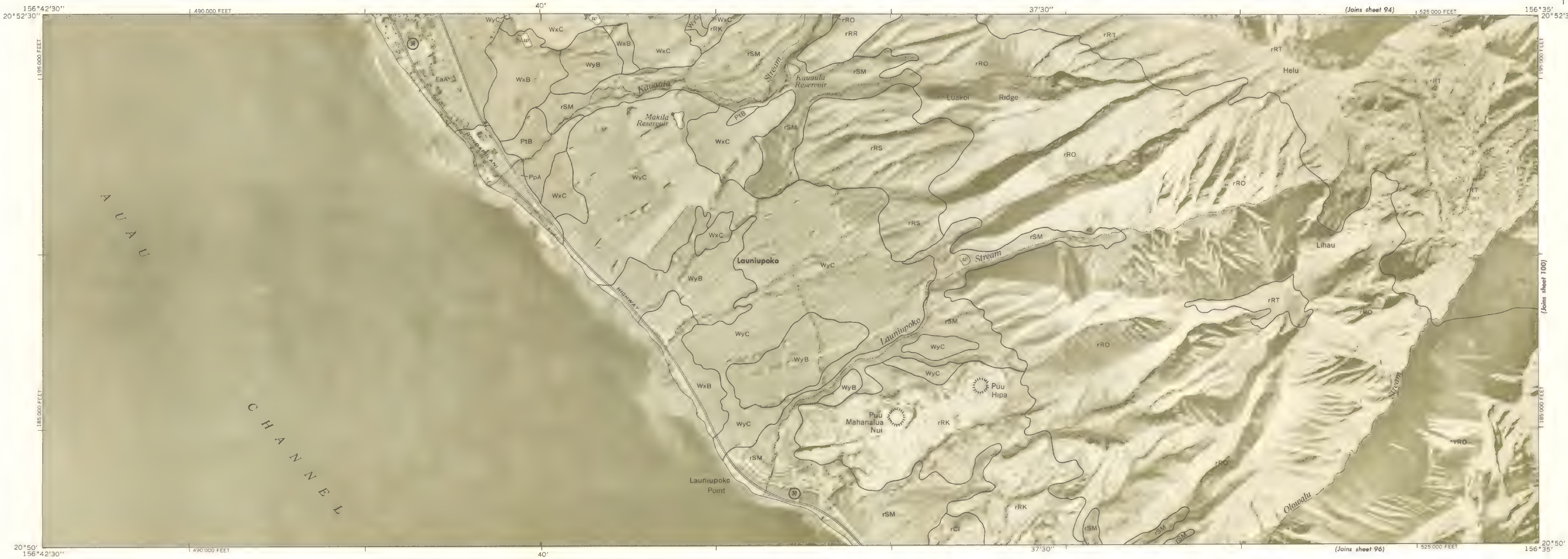
1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2. Old Hawaiian datum.

MAUI ISLAND, HAWAII NO. 94

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.



Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

MAUI ISLAND, HAWAII NO. 95

MAUI ISLAND, HAWAII — SHEET NUMBER 96

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2. Old Hawaiian datum

MAUI ISLAND, HAWAII NO. 96

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station

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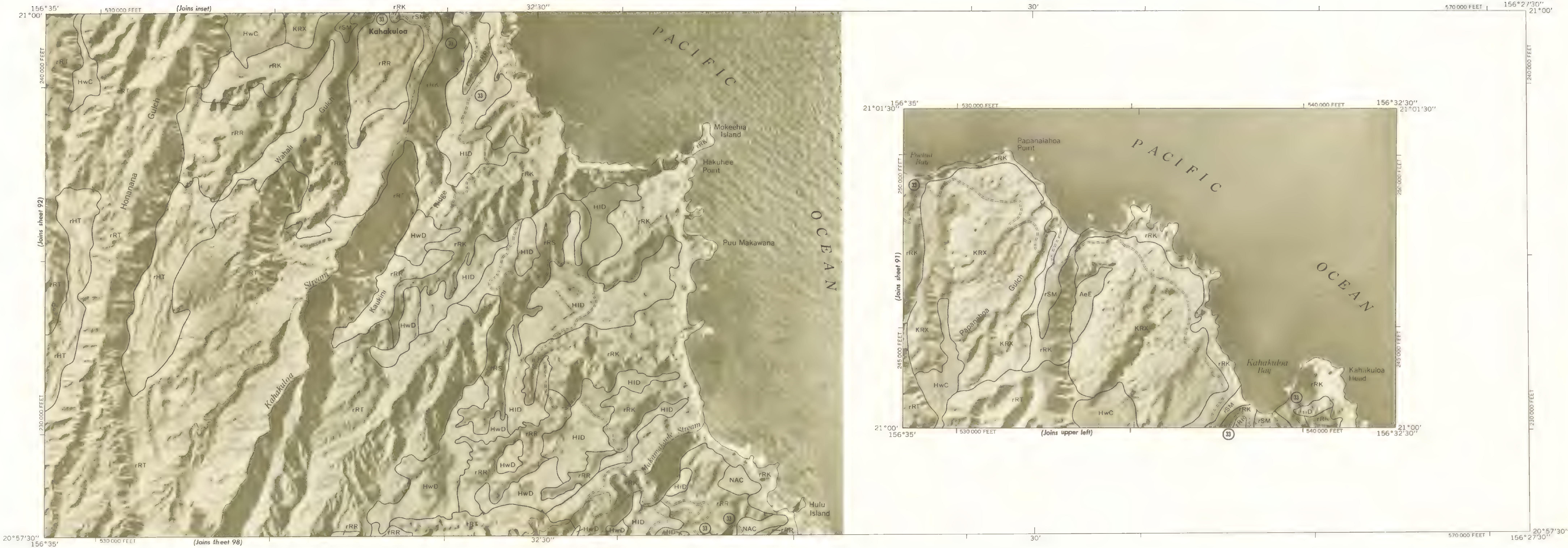
MAUI ISLAND, HAWAII NO. 97

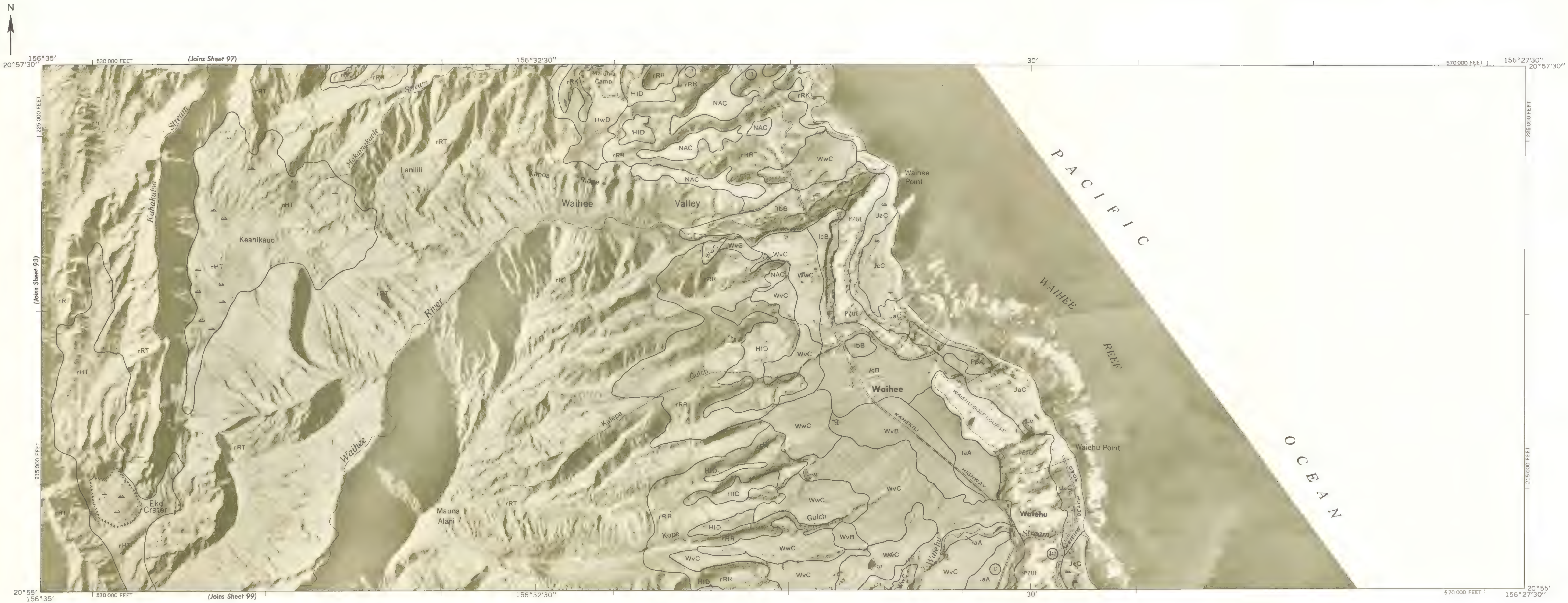


Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet



Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2. Old Hawaiian datum

MAUI ISLAND, HAWAII NO. 98

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station

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MAUI ISLAND, HAWAII NO. 99

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

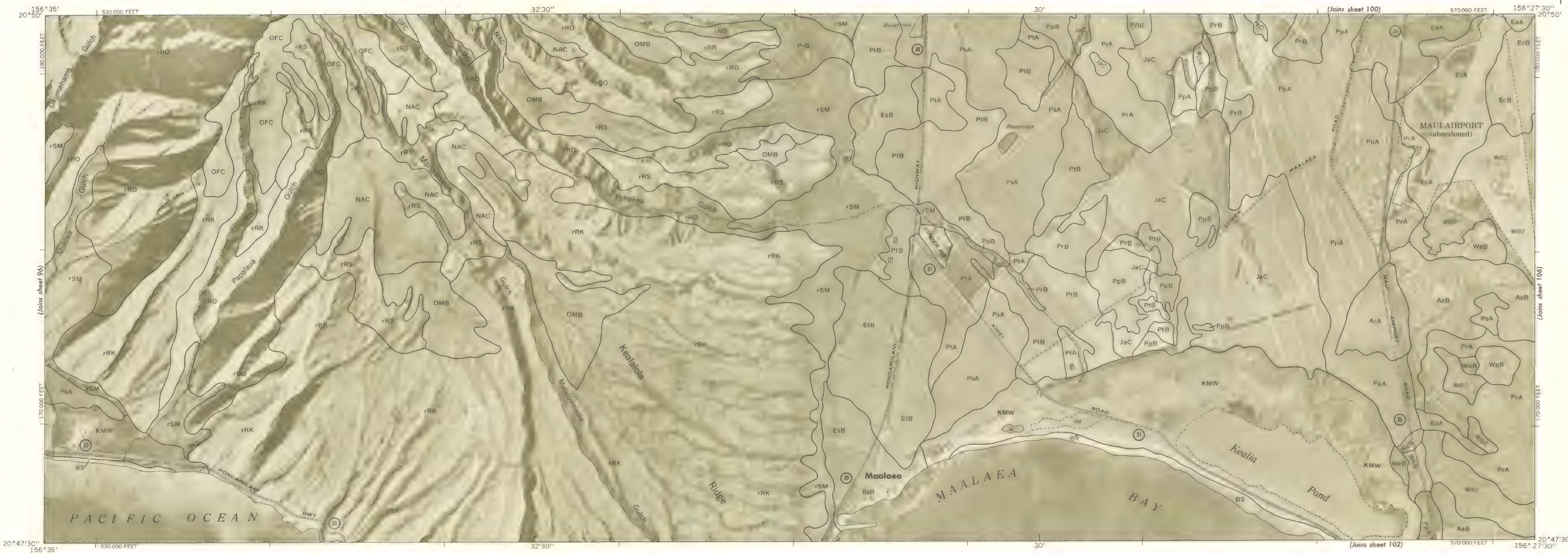
5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2 Old Hawaiian datum

MAUI ISLAND, HAWAII NO. 100

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service and the University of Hawaii Agricultural Experiment Station.

MAUI ISLAND, HAWAII NO. 101



Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

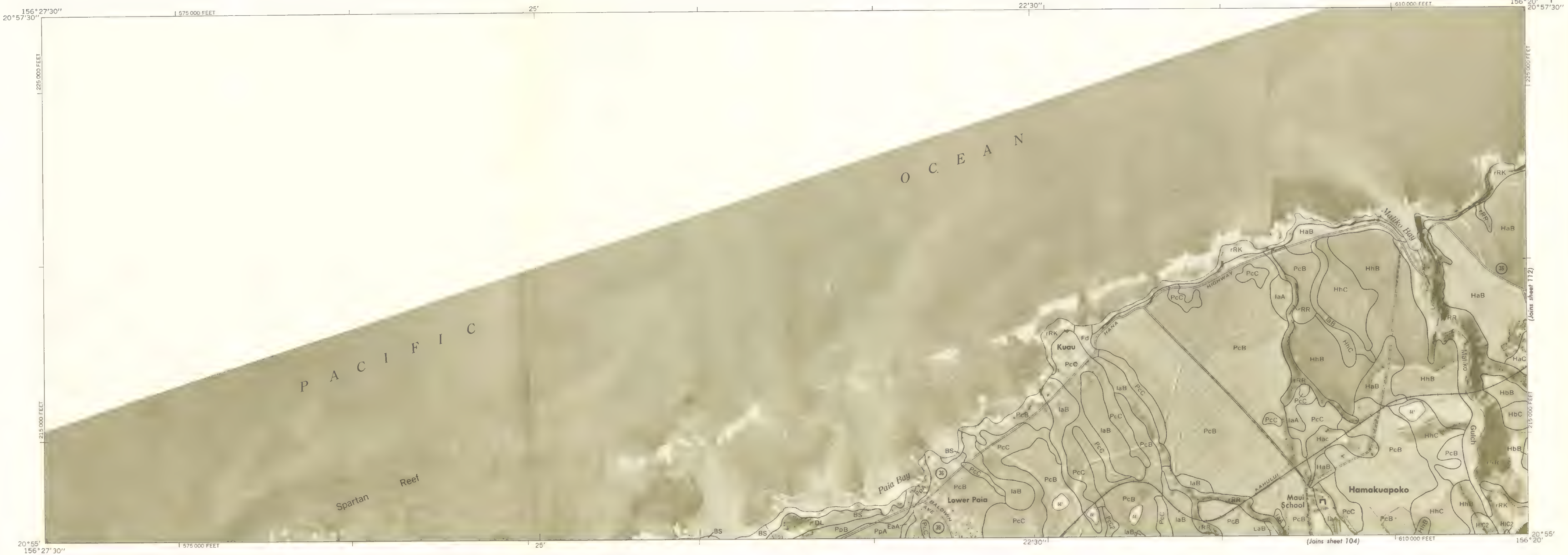
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2 Old Hawaiian datum

MAUI ISLAND, HAWAII NO. 102

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

MAUI ISLAND, HAWAII NO. 103



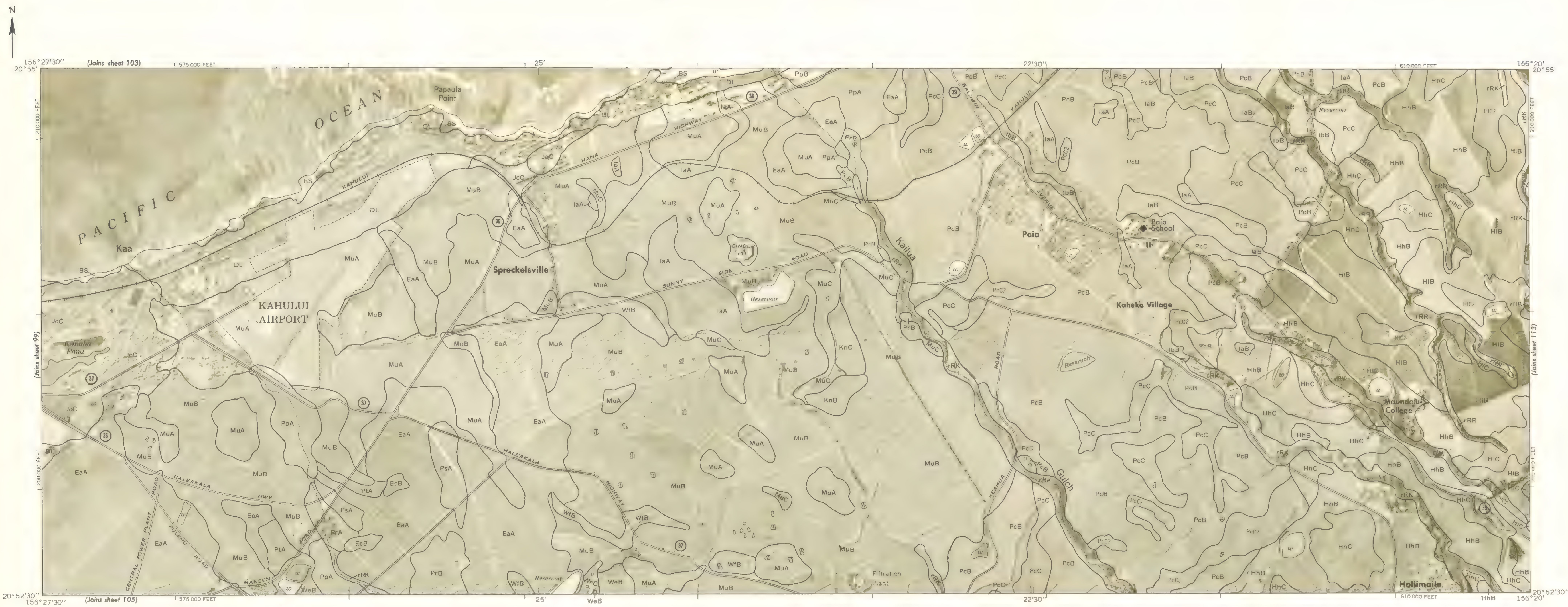
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

MAUI ISLAND, HAWAII — SHEET NUMBER 104



Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2. Old Hawaiian datum

MAUI ISLAND, HAWAII NO. 104

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

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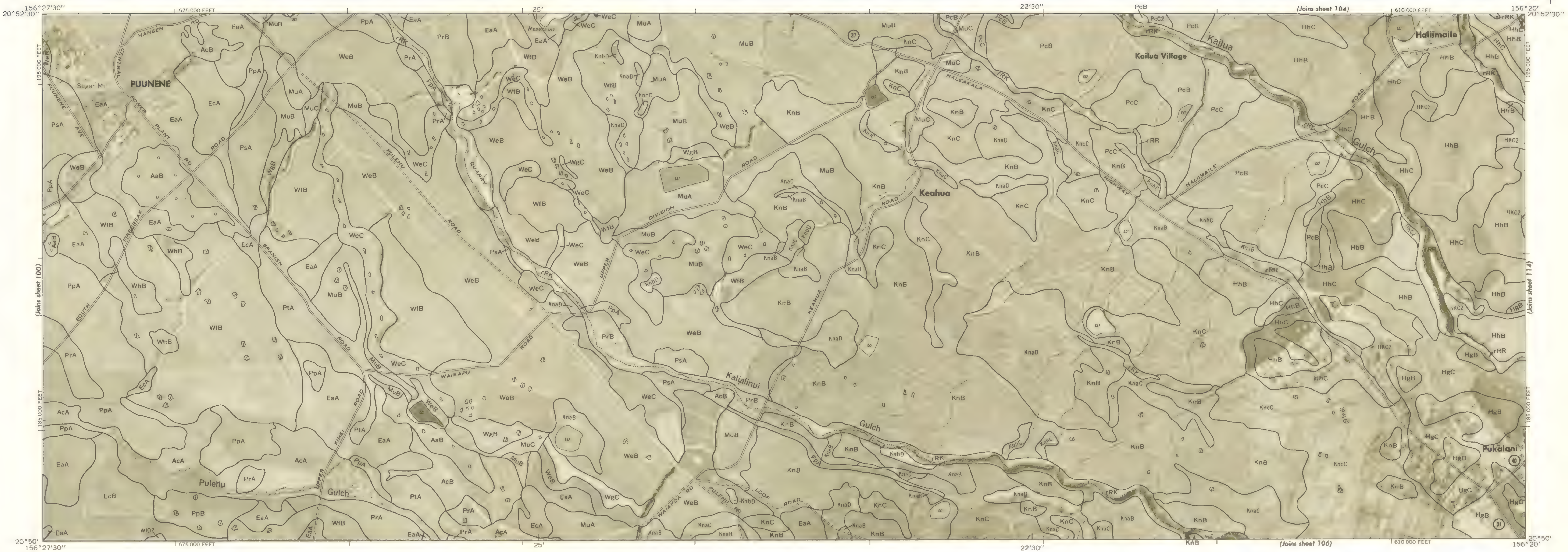
MAUI ISLAND, HAWAII NO. 105



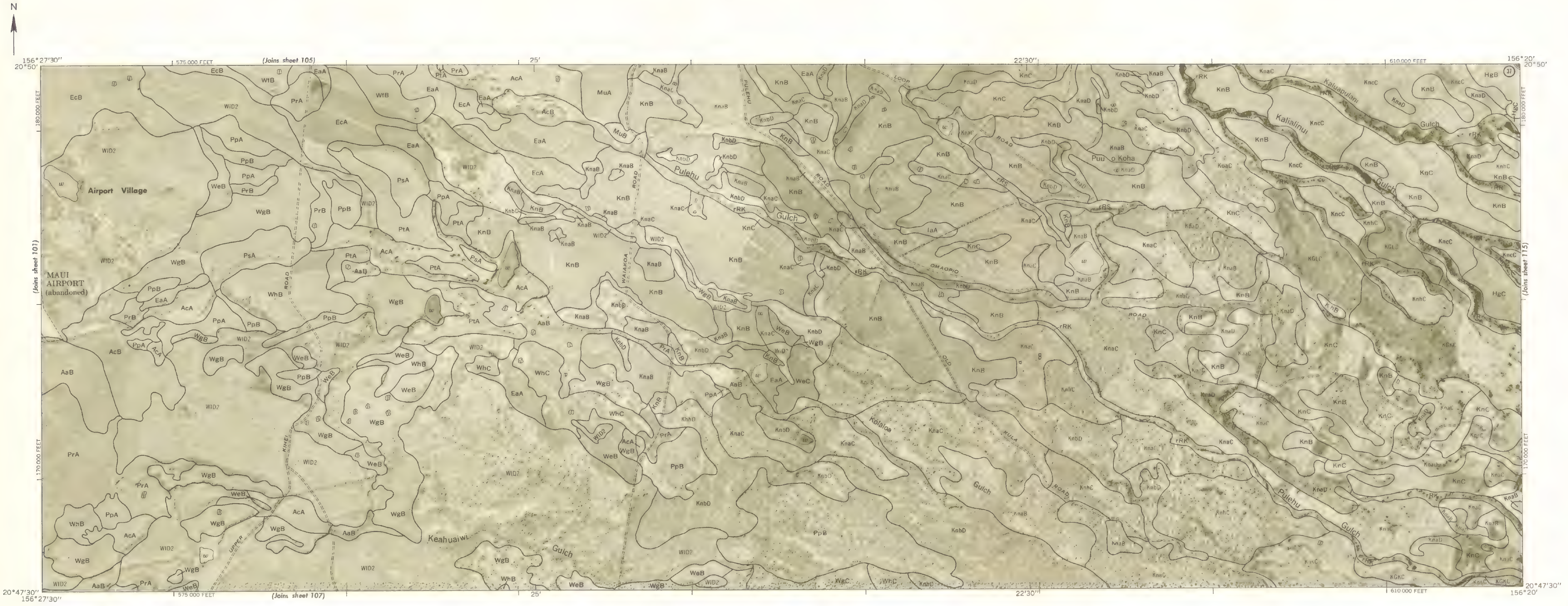
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

MAUI ISLAND, HAWAII — SHEET NUMBER 106



Scale 1:24 000

1 — 3/4 — 1/2 — 1/4 — 0 — 1 — 2 Miles

5 000 — 4 000 — 3 000 — 2 000 — 1 000 — 0 — 5 000 — 10 000 Feet

Photobase from 1965 aerial photographs. 5,000 foot grid ticks based on Hawaiian plane coordinate system, zone 2 Old Hawaiian datum.

MAUI ISLAND, HAWAII NO. 106

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

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This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station

MAUI ISLAND, HAWAII NO. 107

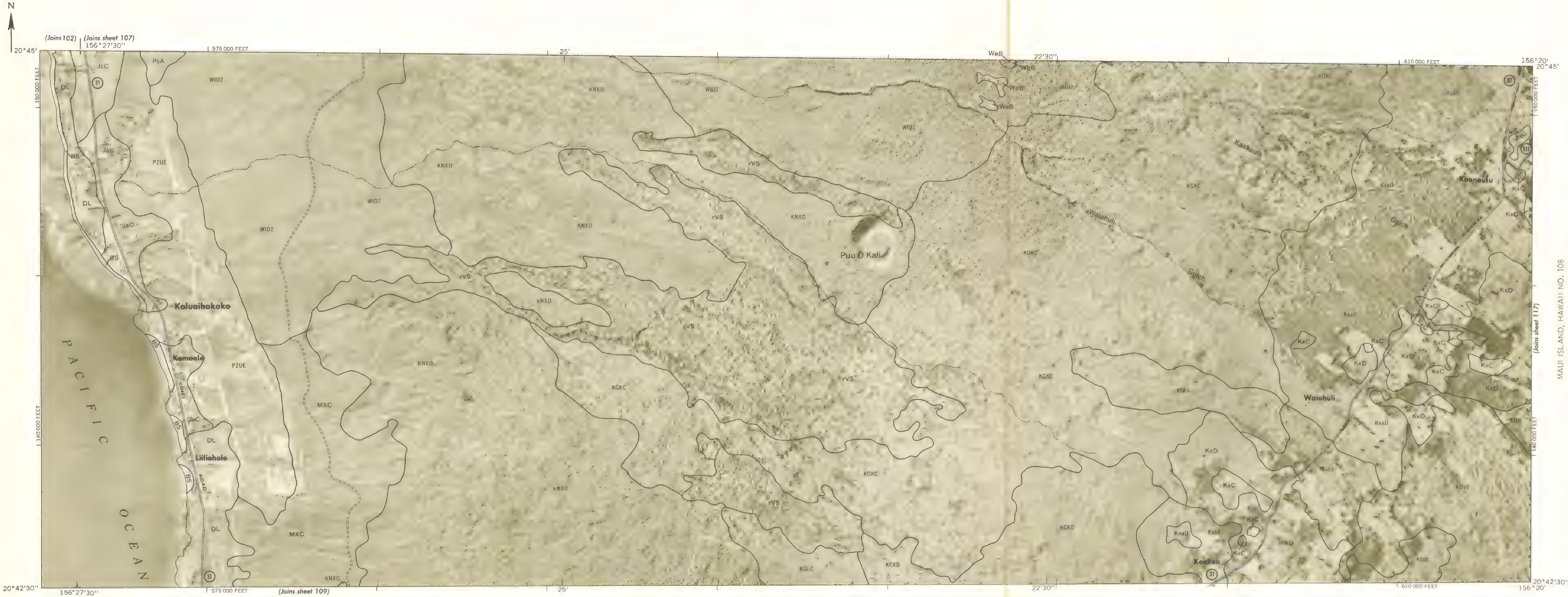
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

MAUI ISLAND, HAWAII — SHEET NUMBER 108



Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2. Old Hawaiian datum.

MAUI ISLAND, HAWAII NO. 108

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

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MAUI ISLAND, HAWAII NO. 109

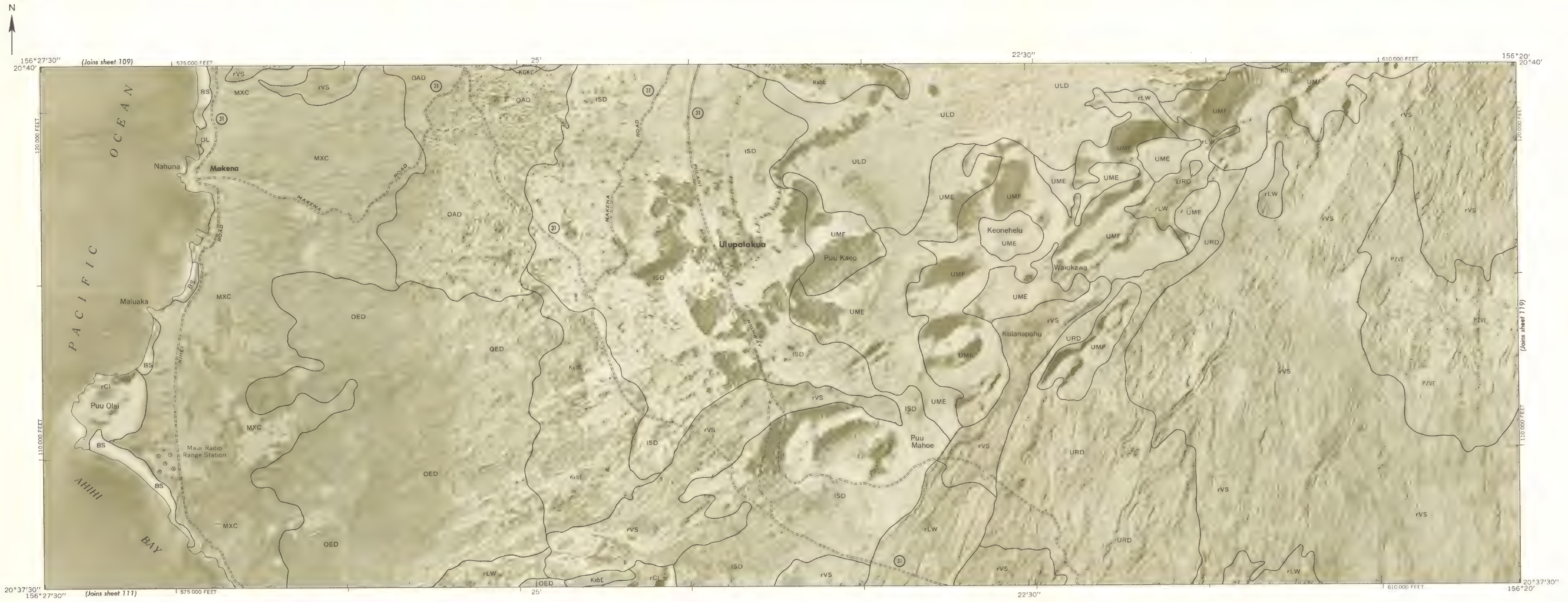
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

MAUI ISLAND, HAWAII — SHEET NUMBER 110



Scale 1:24 000

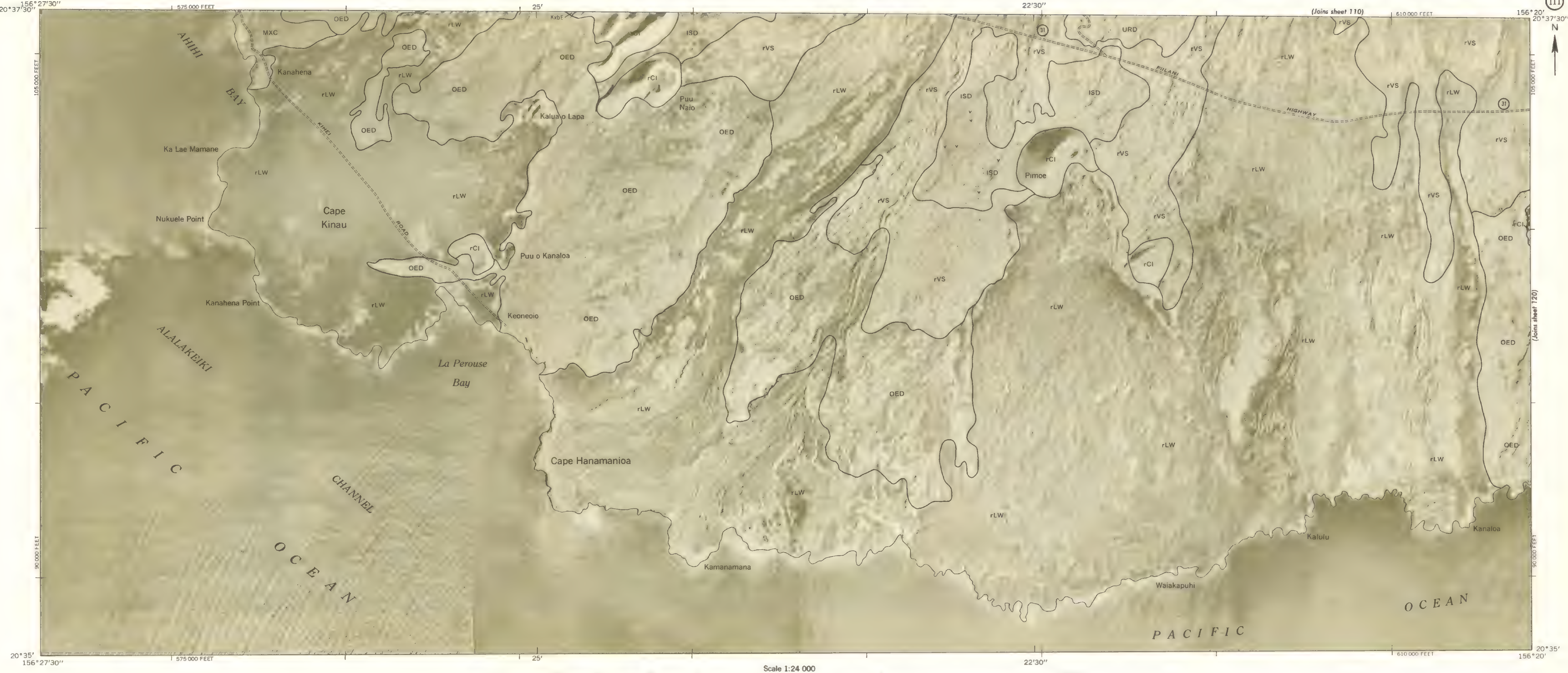
1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2. Old Hawaiian datum.

MAUI ISLAND, HAWAII NO. 110

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.



Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

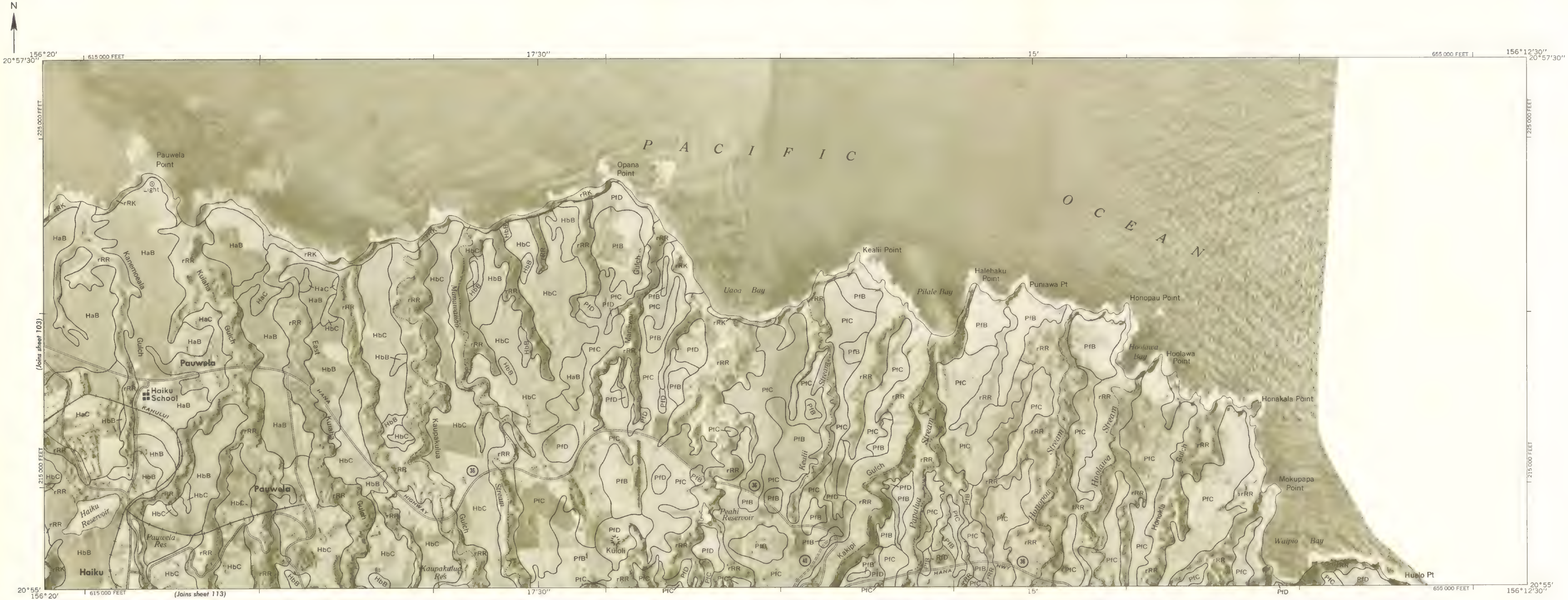
5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2. Old Hawaiian datum.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

MAUI ISLAND, HAWAII NO. 111

MAUI ISLAND, HAWAII — SHEET NUMBER 112



Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2. Old Hawaiian datum.

MAUI ISLAND, HAWAII NO. 112

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MAUI ISLAND, HAWAII NO. 113

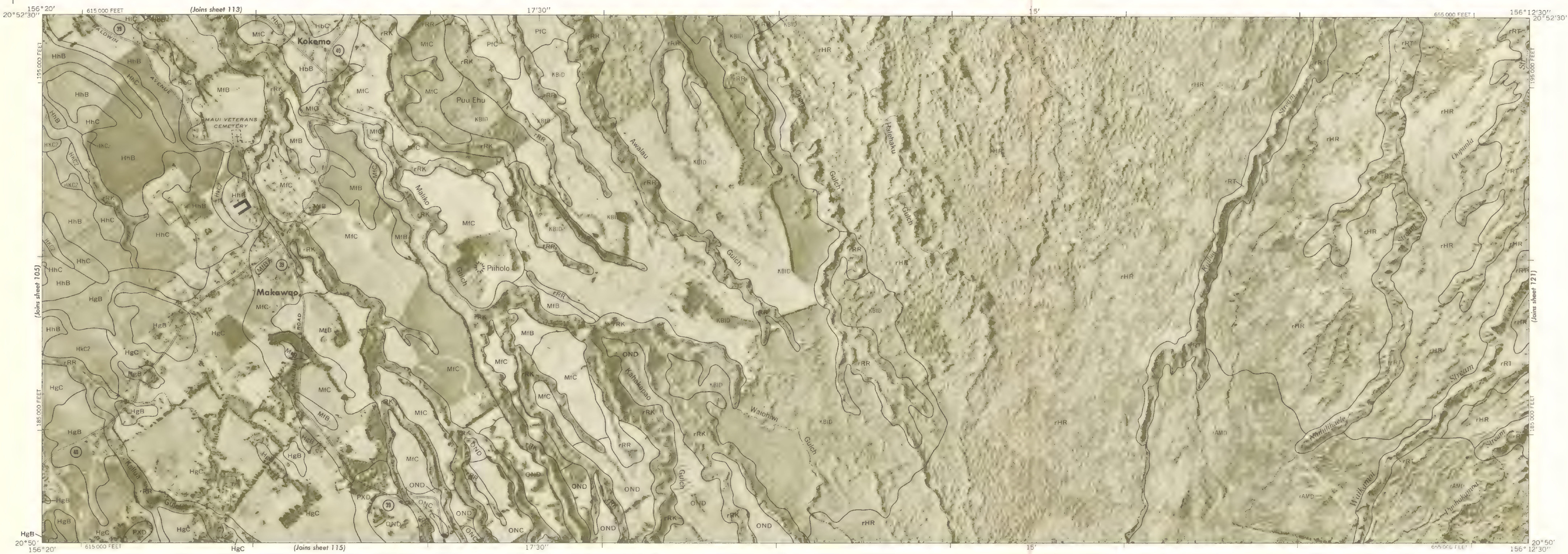
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

N



Scale 1:24 000

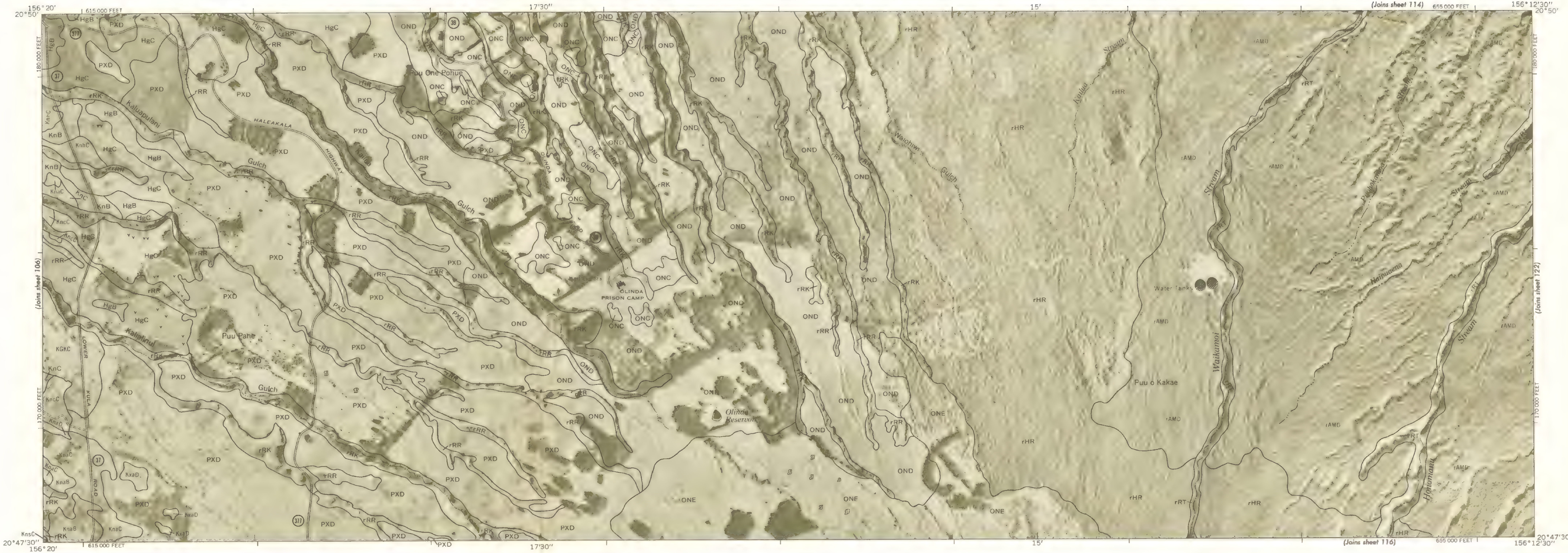
1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

Photobase from 1965 aerial photographs. 5,000 foot grid ticks based on Hawaiian plane coordinate system, zone 2. Old Hawaiian datum.

MAUI ISLAND, HAWAII NO. 114

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.



This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

MAUI ISLAND, HAWAII NO. 115

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

MAUI ISLAND, HAWAII — SHEET NUMBER 116

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2. Old Hawaiian datum.

MAUI ISLAND, HAWAII NO. 116

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

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MAUI ISLAND, HAWAII NO. 117

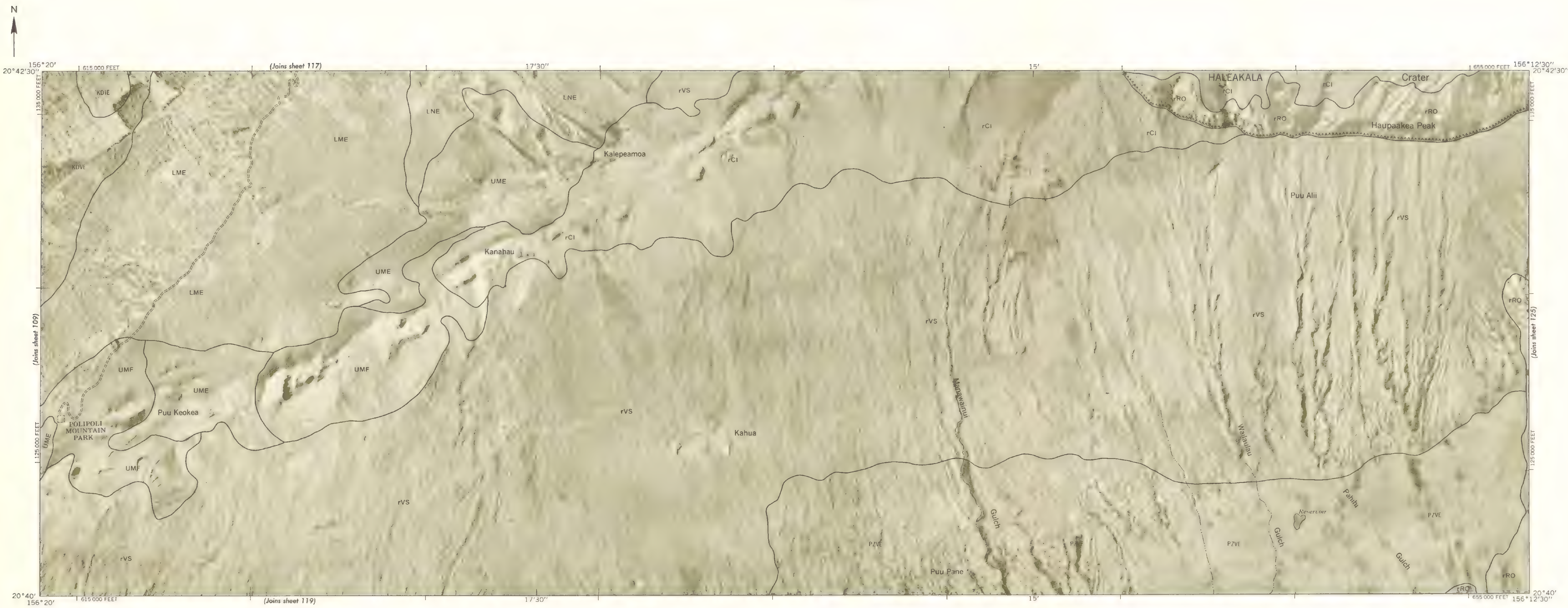
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

MAUI ISLAND, HAWAII — SHEET NUMBER 118



Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2 Old Hawaiian datum.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

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This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

MAUI ISLAND, HAWAII NO. 119

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

MAUI ISLAND, HAWAII — SHEET NUMBER 120

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2. Old Hawaiian datum.

MAUI ISLAND, HAWAII NO. 120

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

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MAUI ISLAND, HAWAII NO. 121

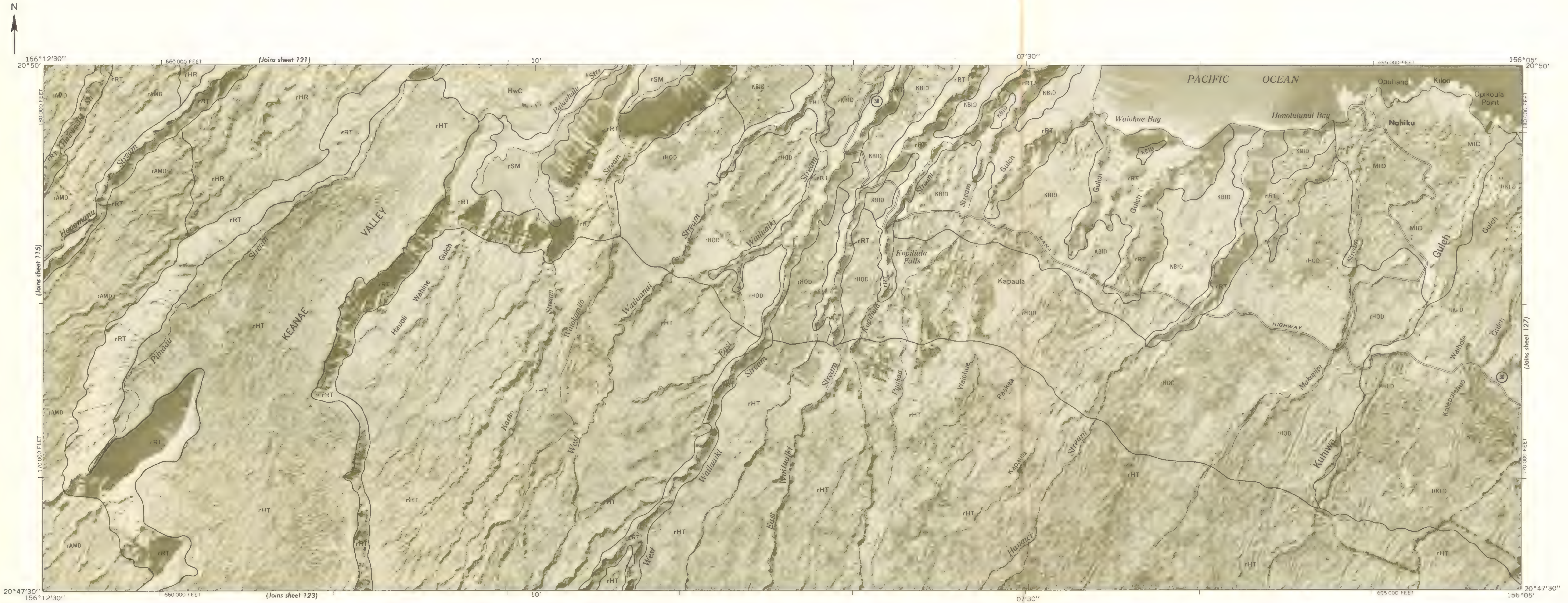
Photobase, from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2 Old Hawaiian datum

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

MAUI ISLAND, HAWAII — SHEET NUMBER 122



Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2. Old Hawaiian datum

MAUI ISLAND, HAWAII NO. 122

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MAUI ISLAND, HAWAII NO. 123

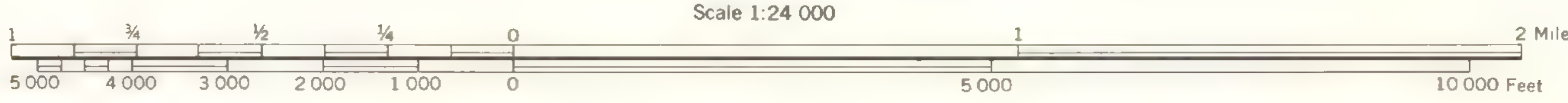
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

MAUI ISLAND, HAWAII — SHEET NUMBER 124



Photobase from 1965 aerial photographs. 5,000 foot grid ticks based on Hawaiian plane coordinate system, zone 2 Old Hawaiian datum.

MAUI ISLAND, HAWAII NO. 124

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

MAUI ISLAND, HAWAII NO. 125

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2 Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

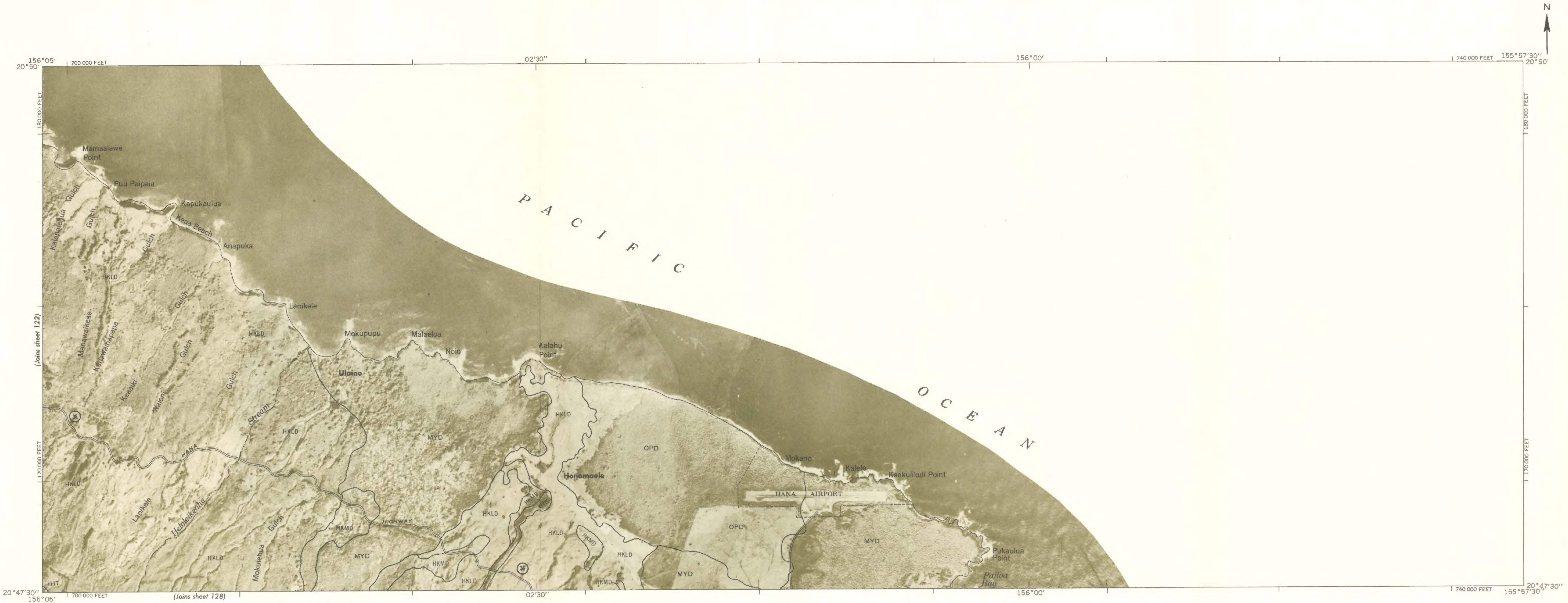
5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

MAUI ISLAND, HAWAII NO. 126

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

MAUI ISLAND, HAWAII NO. 127



Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

MAUI ISLAND, HAWAII — SHEET NUMBER 128

Scale 1:24 000

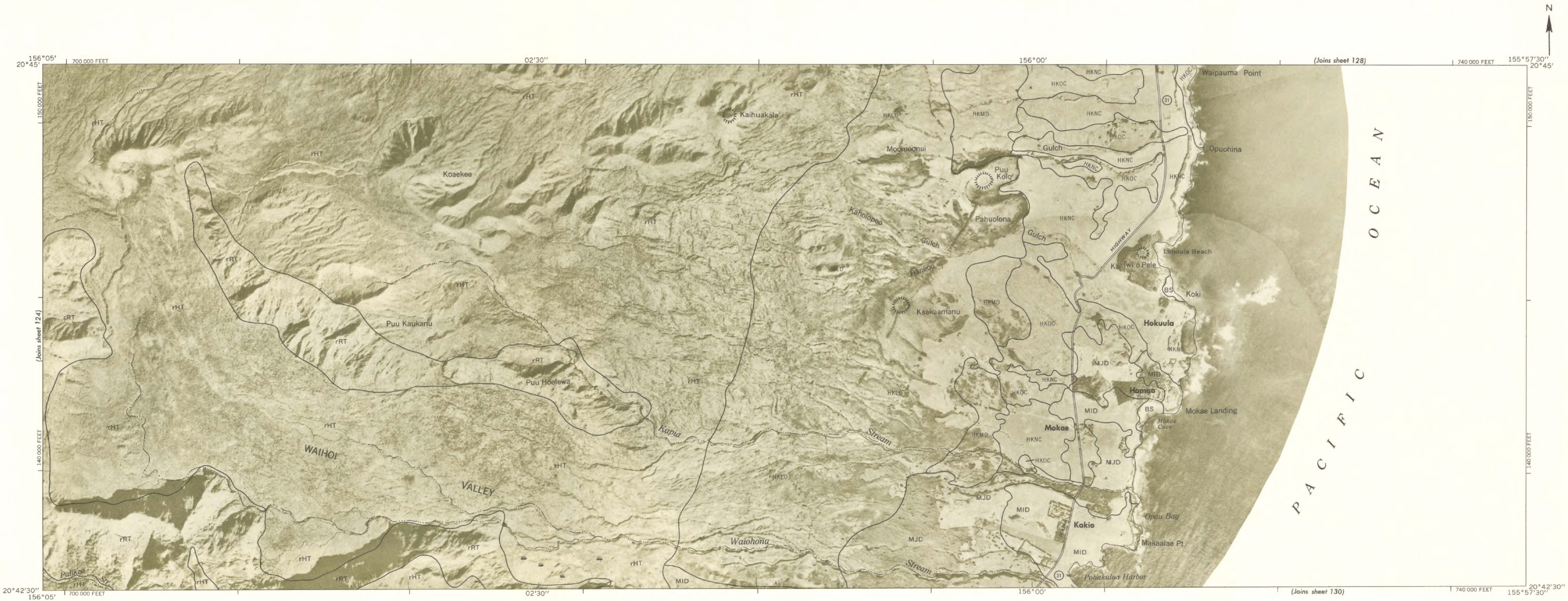
1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2. Old Hawaiian datum.

MAUI ISLAND, HAWAII NO. 128

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.



This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

MAUI ISLAND, HAWAII NO. 129

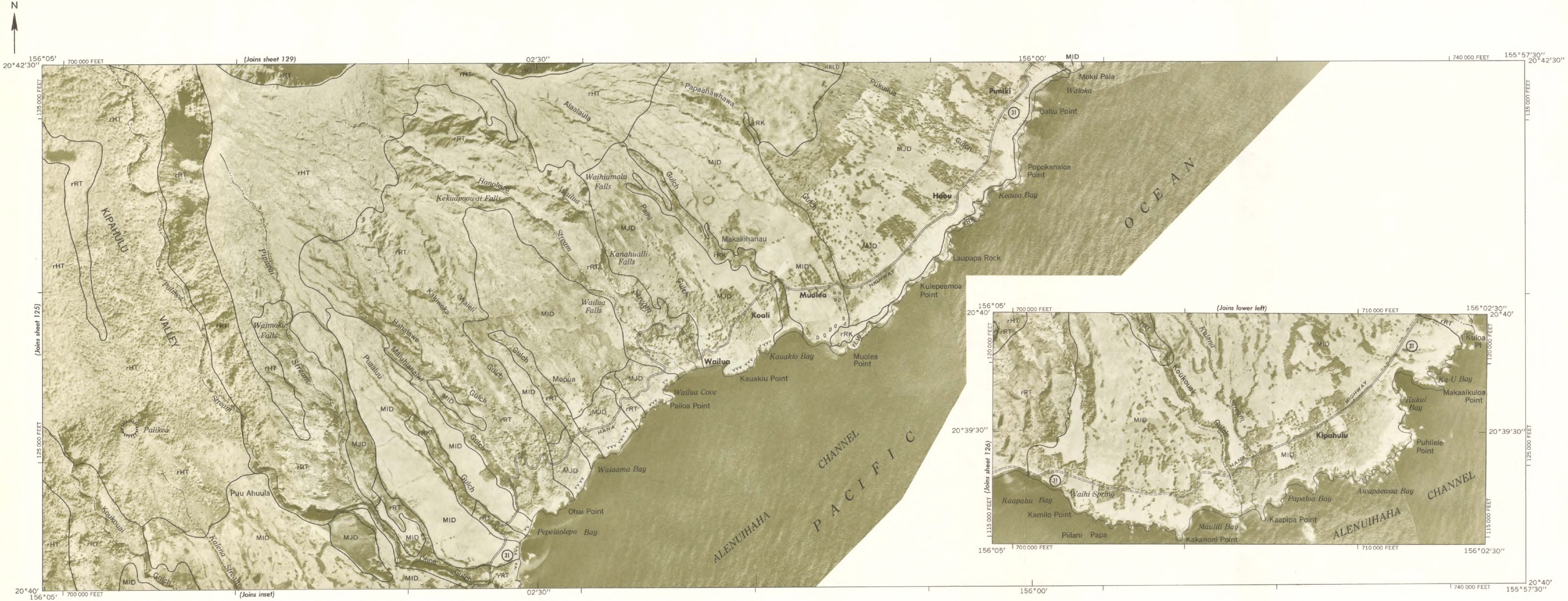
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

MAUI ISLAND, HAWAII — SHEET NUMBER 130



Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5 000 4 000 3 000 2 000 1 000 0 5 000 10 000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2. Old Hawaiian datum.

MAUI ISLAND, HAWAII NO. 130

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.